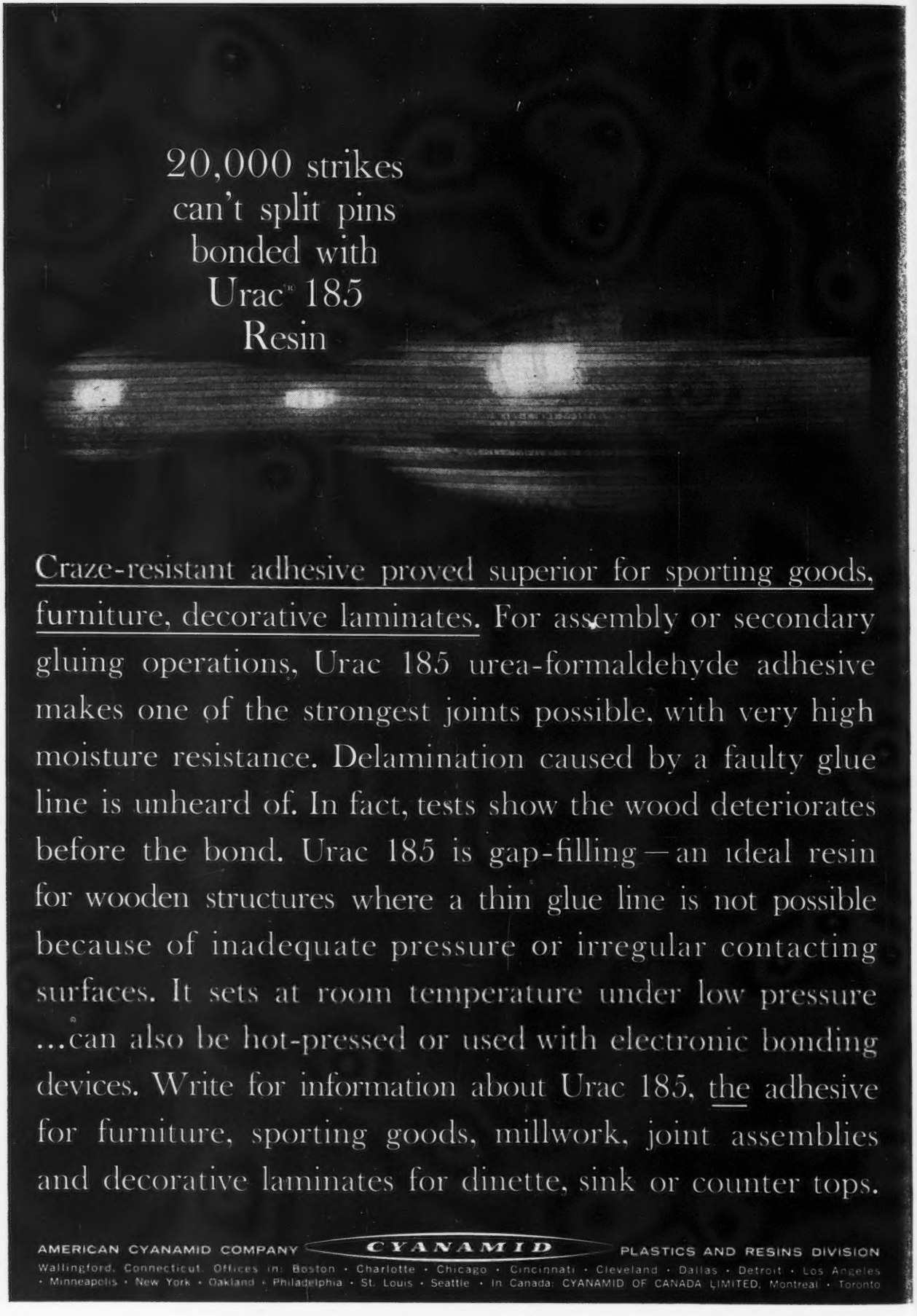
FOREST PRODUCTS JOURNAL

FOREST PRODUCTS RESEARCH SOCIETY

PRE-CONVENTION ISSUE: Meet Donald K. Saunders, FPRS 15th President

Vol. XI, No. 6

1961 / JUNE



Craze-resistant adhesive proved superior for sporting goods, furniture, decorative laminates. For assembly or secondary gluing operations, Urac 185 urea-formaldehyde adhesive makes one of the strongest joints possible, with very high moisture resistance. Delamination caused by a faulty glue line is unheard of. In fact, tests show the wood deteriorates before the bond. Urac 185 is gap-filling—an ideal resin for wooden structures where a thin glue line is not possible because of inadequate pressure or irregular contacting surfaces. It sets at room temperature under low pressure ...can also be hot-pressed or used with electronic bonding devices. Write for information about Urac 185, the adhesive for furniture, sporting goods, millwork, joint assemblies and decorative laminates for dinette, sink or counter tops.

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Circle Item 1, Reader Service Form

A STATEMENT OF IMPORTANCE TO THE FOREST PRODUCTS INDUSTRY

If you have the problem of wood waste—consider chipping your slabs, edgings and other by-products into valuable, profit-making wood chips.

Each Load Brings Ready Cash

Wood chips are becoming an increasingly profitable outlet for wood waste from sawmills and woodworking plants. Wood chips are needed by farmers, nurserymen and others, for litter, mulch, erosion control, and for many additional uses. You can therefore get ready cash for wood chips—in some areas they bring about $22.50 a load (2 cords), considerably more than sawdust or shavings.

So if you want to turn wood by-products into saleable, valuable chips, consider installing a Fitchburg Chipper. This is the proved way to fully utilize wood waste *while reducing* the costly labor of hauling it away or burning it. One installation brings you income year after year.

Slab to Chips in 20 Seconds

The Fitchburg Chipper is a relatively small machine, not one of the big chipping "hogs." It doesn't take up much room, can be installed inside or outside, can even be powered by your own engines. Yet it will take slabs as wide as 14½" and chip them up in no time at all—in about 10 to 20 seconds (depending on conditions).

Smooth and Safe

The Fitchburg Chipper can be set up for either vertical *or* horizontal feeding. Chipping is smooth and *safe* because of the patented spring activated feed plate, exclusive with Fitchburg. You can easily adjust the *size of the chip* from about ¼" to approximately 3". And if your scrap wood is in one area of the plant, and you want the chips elsewhere, just attach a blower and pipe to the Chipper and you can blow the chips exactly where you want them—no extra hauling labor.

FITCHBURG ENGINEERING CORPORATION FITCHBURG, MASS.

Growing Market for Chips

There's a new, growing market for wood chips as a mulch on shrub beds along roadsides. Several state highway departments now *specify* wood chips for plantings along highways to reduce costly hand weeding, cut maintenance costs. Chips choke out the weeds, hold in moisture, prevent erosion; this is specially important for new plantings in parks and along the many miles of new highways.

Nurserymen can't get enough because they find chips make a perfect mulch, which slowly develops into high grade compost.

Poultrymen pay premium prices for wood chip litter because wood chips are highly absorbent, less dusty and don't pack like most litters. Wood chips are specially popular in the many broiler areas; the market for broiler litter is big because houses are cleaned out every ten weeks. Dairymen find that chips make absorbent bedding that's easy to clean out. Orchardists use chips, and in one area grape growers report that chips from a plant manufacturing tenpins actually *saved* their vineyards.

FREE: We'll gladly tell you more about these markets by sending you case histories with names and addresses of persons and companies making money from chips in numerous ways. These were written up in leading publications and the *complete* story is yours for the asking, at no obligation. Mail the coupon, tell us your wood waste problem, send for free information and booklet.

FITCHBURG ENGINEERING CORPORATION
Department FPJ-16
Fitchburg, Massachusetts

Please send more information about selling wood chips for Highways ☐ Poultry ☐ Other_____

Our wood by-products consist of Slabs ☐ Edgings ☐ Others, specify_____

Please send the free booklet "Make Low-Cost Bedding, Litter, Mulch" ☐ Please send specifications and prices for Fitchburg Chippers ☐

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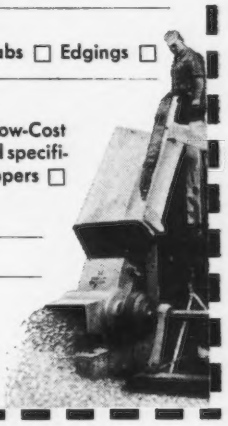
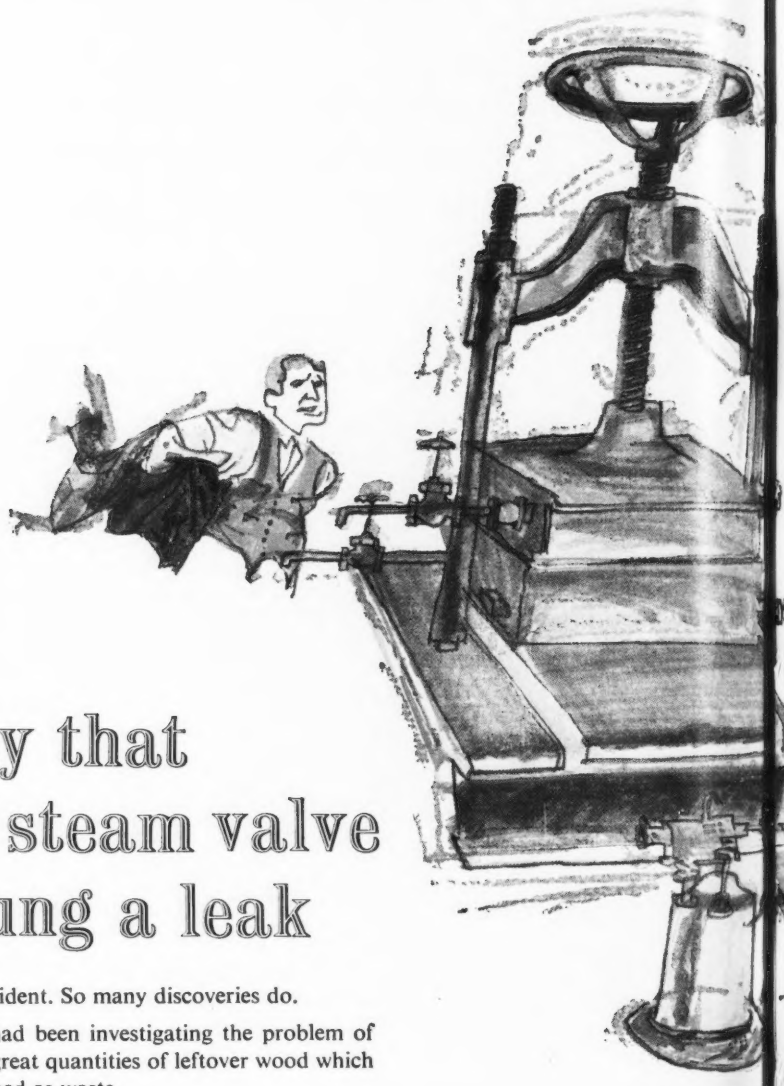
Address_____

Town_____

State_____





the day that Mr. Mason's steam valve sprung a leak

It started with an accident. So many discoveries do.

William H. Mason had been investigating the problem of what to do with the great quantities of leftover wood which sawmills usually burned as waste.

By a unique explosion process, he had discovered how to reduce the wood to its strong, component fibers.

But he didn't really find hardboard until the day his steam valve sprung a leak.

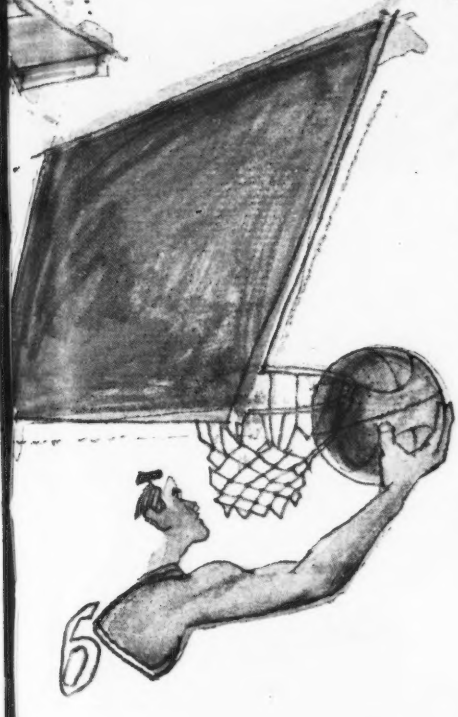
He had built a small forming machine for making wetlap. Placing some of the wetlap in a steam-heated screw press, he intended to squeeze out the water and then dry the board in an oven.

Circle Item 5, Reader Service Form

He turned off the steam when he left for lunch, but on returning discovered that the press was still hot. The valve had sprung a leak, and his piece of wetlap had turned into a hard, dense, dry board. It wouldn't split, splinter, crack, dent or snag.

This was the world's first piece of hardboard.

Since that time, the uses for Masonite hardboard have become practically limitless. It is found everywhere in the home furnishings field: as walls, doors, ceilings, siding, and in almost all types of furniture.



Masonite hardboard is so versatile (in its hundreds of types, thicknesses, textures and sizes) that it can be used for boat decks or basketball backboards, for refrigerators or photo albums, for railroad cars or billiard table tops.

Almost anything that stands, lies flat, sits up, supports, contains, remains stationary, or moves by wheel, wind or water has some use for Masonite hardboards.

And that's really using wood to its fullest extent.

Masonite Corporation, Dept. FPJ-6, Box 777, Chicago 90, Illinois.

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CORPORATION

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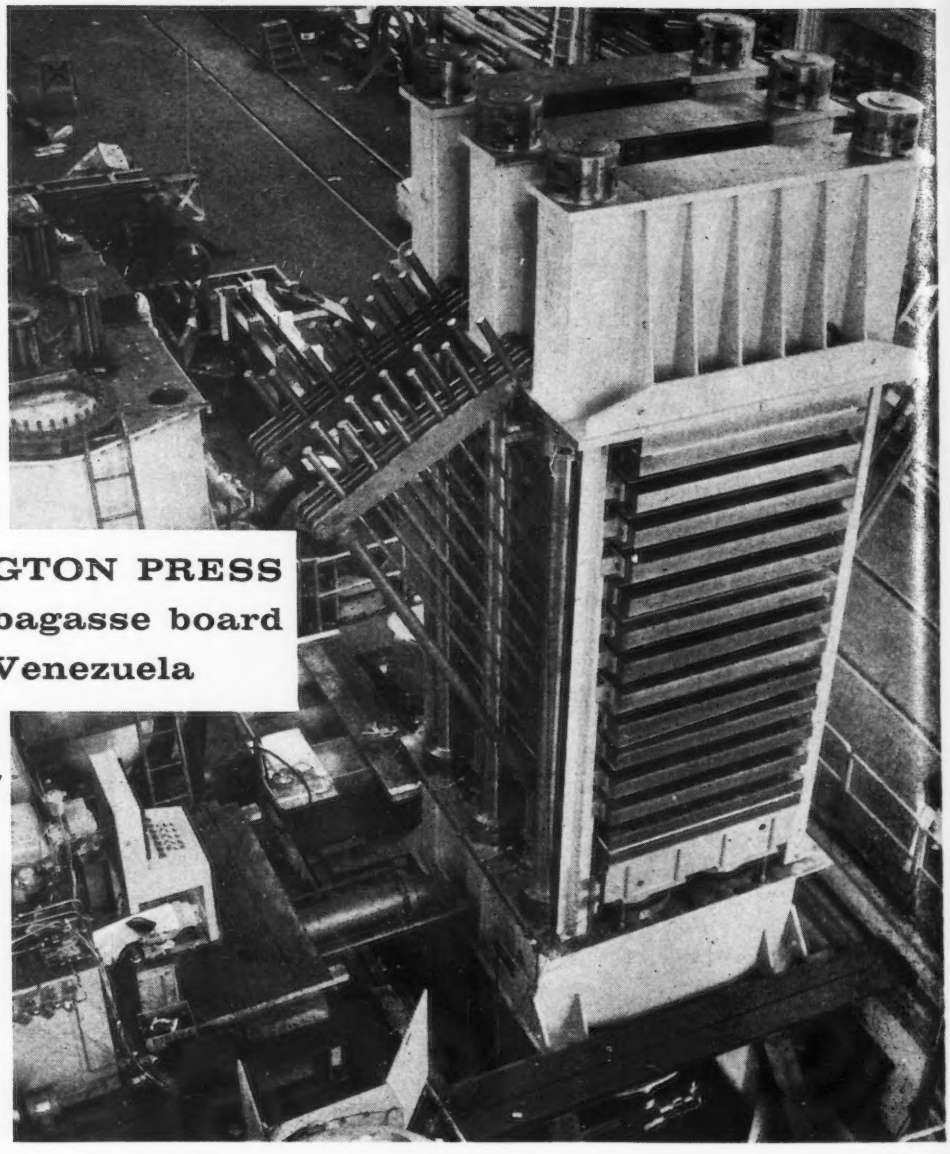

New WASHINGTON PRESS pre-tested for bagasse board production in Venezuela

Product: Bagasse softboard, composition board and hardboard.

Owner: Tablopan de Venezuela, Caracas.

Plant Engineers: Columbia Engineering Co., Eugene, Ore.

South America now joins the continents of Australia, Asia, Europe and North America in the worldwide span of Washington hydraulic press installations.

One reason for preference is indicated in the view above—the facilities to pre-assemble and test at the factory presses designed for utmost dependability, accuracy and flexibility of production at remote plant sites.

If you are now considering a new board plant, we cordially invite your inquiry at the earliest stage of planning. Write or call Washington Iron Works, 1500 Sixth Ave. South, Seattle 4, Washington.

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SPECIAL HYDRAULIC PRESSES • AUTOMATIC PRESS LOADERS AND UNLOADERS • COMPLETE DRY PROCESS HARDBOARD AND PARTICLE BOARD FORMING LINE EQUIPMENT

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FOREST PRODUCTS JOURNAL

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FPRS News-Digest

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A Message from the President

. . . Raymond H. Berry

WITH this June issue of the *JOURNAL* we come to the Annual Meeting at Louisville and the annual change of Executive Board Officers. It has been a very active year for our Society, nationally, within the Sections, and within the new Divisions. Our new dues went into effect, along with the change in the Constitution and Bylaws that established the Divisions as a part of the structure of the Society and changed their approach from product orientation to process orientation. Art Muschler, Don Saunders, and Tony Veazey all contributed much to this change in our Constitution and Bylaws. Art, as Chairman of the Committee on Constitution and Bylaws, has some further suggestions that will come up with regard to a constitutional change in the dues structure for Supporting Memberships. In this, he has been assisted by a survey made by Charles Kreider as Chairman of a Ways and Means Committee appointed by the Board.

Don Saunders, our President Elect, who will assume his new duties as President at the end of the Louisville meeting, has been in charge of the first technical program under the new Division set-up, and Tony Veazey has been engaged in a reorganization of the new Divisions.

During the year, the newly appointed Executive Committee has functioned along with the Board, and—with the able assistance of Jim Love, Chairman of the Budget and Finance Committee—a new system of accounting has been installed so that the accounting of the Society is now established on a sound accrual basis.

Changes have been made by the Board with regard to the *JOURNAL*, and under the new set-up Editor John McDonald is overcoming the lag in publication. Beginning with this issue, the *JOURNAL* will come out each month on time.

Special attention has been paid to membership increase and membership records. Under Walt Smith's able guidance as National Membership Chairman, we now have at the National Office an up-to-the-minute record of the membership by classifications and by geographical distribution.

The Board has established a new standing committee, to be known as the Policy Committee, which will be composed of all of the Past Presidents of the Society. This is a system which has worked well in other organizations, such as the National Lumber Manufacturers Association. In a rapidly moving world it is necessary that the Society keep in step with the times, and utilization of the experience of those who have held the office of President is believed to be a means of keeping our organization dynamic. The "ground rules" for this new Committee are now under consideration by the Executive Board.

A new Committee has also been appointed to develop a system for handling of exhibits at our Annual Meetings which should prove to be a source of revenue for the Society in the future.

In all the changes outlined, our new Executive Secretary, Ken Huddleston, has been efficiently at work. Office practices have been reorganized and the staff, as now constituted, is working superbly as a team under his leadership. Among other changes in the office has been the acquisition of new offset printing equipment, which adds greatly to the effectiveness of office procedure and increases the Society's income as well as reducing its expenditures.

For those engaged in the wood industry, this has been a year of bad markets, changing practices, and economic confusion. This, of course, has had its impact upon all organizations that have to do with wood. The Society, however, through the effective teamwork of Ken Huddleston and the staff at the National Office, and the devoted services of those on the Executive Board and the Executive Committee, is on a firm basis and moving steadily forward. In this connection there should be mentioned the invaluable counsel of our Past President, Scotty Harrar, who, although suffering under severe physical handicaps throughout the year, has given largely of his time and wisdom toward this progress.

In closing this last President's message during my term of office, I want to thank all of those members of the Board and the staff who have worked so hard to advance the interests of the Society. It has been an illuminating and rewarding experience for me, as well as a deeply appreciated honor.

Wilson Wyatt to Address FPRS Luncheon, June 20

Guest speaker at the Official FPRS Luncheon, Tuesday, June 20, in Louisville, Ky., will be Wilson W. Wyatt, Lieutenant Governor of the Commonwealth of Kentucky, and a major figure in that State's recent efforts to develop a sound program of protection, reforestation, and scientific management designed to improve the forests that cover 45 percent of Kentucky's total land area.

A nationally recognized attorney, with an impressive list of contributions to public service on local, state, and national levels, Wyatt has always maintained a strong interest in conservation, forestry, and wood utilization. He is an active tree farmer and serves as a director of the Forest Farmers Association, which covers a 13-state area. He is also an honorary vice president of the American Forestry Association.

Lt. Governor Wyatt has been a leading influence in Kentucky's renewed interest in forestry, and he was a strong advocate for a strengthened and expanded Division of Forestry in the Department of Conservation, a development that resulted in the doubling of state appropriations for that agency.

He was also instrumental in the establishment of a Wood Utilization Division in the Department of Economic Development. The purpose of this new agency, according to Wyatt, is to increase the economic benefits to Kentuckians from the timber they grow by promoting the manufacture of wood products in the State.

"We are convinced that forestry is on the way to becoming a major industry in Kentucky's economy," he said recently, "and our purpose is to move forward on the broad front of planting, improved forest practices, sound management, and research on wood utilization."

A former mayor of Louisville, Wyatt also served as Housing Expeditor and Administration of the National Housing Act in 1946. He is a member of the American Bar Association, the Board of Directors of America Heritage Foundation, and of the American Abitrator Association.

His interest in city government and his service to education are also well known. He has served as president of both the Kentucky Municipal League and the American Municipal Association. He is a former chairman of the Board of the University of Louisville, and is currently a member of the National Citizens Council for Better Schools.

Lt. Governor Wyatt is recognized as an accomplished public speaker and raconteur. This coupled with his extensive public service and his deep interest in the problems of the forest products industry should insure an informative and entertaining address.

Official Program for FPRS 15th Annual Meeting, Louisville, Ky., June 18-22

THE KENTUCKY HOTEL, in the heart of Louisville, will be headquarters during the 5 full days of the Society's 15th Annual Meeting, June 18 through June 22.

The technical program will feature 16 technical sessions in which 60 authoritative reports and panel discussions on the latest developments in wood technology will be presented by world-recognized research and management personnel.

First Day Events

Activities on Sunday will include meetings of the Executive Board, the Publications Committee, the National Membership Committee, the Employment Committee, and the Tellers' Committee. The Registration Desk will be open from 1:00 to 8:00 p.m., and an informal Hospitality Hour will be held from 6:30 to 7:30 p.m.

Keynote Address Monday

The theme of the meeting, "Products Development—Keystone to Expanded Markets," will be set by keynote speaker, C. B. Dosker, president, Gamble Bros., Inc., Louisville. A. B. Hood, Ralph L. Smith Lumber Co., Anderson, Calif., and current president of the National Lumber Manufacturers Association, will also address the general session.

Award Presented

The general session will conclude with the presentation of the 1961 Hitchcock Award, sponsored by the Hitchcock Publishing Co., and the presentation of the 12th Annual Wood Awards, sponsored by Wood and Wood Products Magazine.

Business Meetings

The 15th Annual Business Meeting will convene at 10:00 a.m., following the general session. Results of the Society's elections will be announced, and other important business will be conducted.

Division business meetings are scheduled for Tuesday afternoon, and the Section and Division Advisory Committees will meet Tuesday evening.

Social Activities

The traditional Paul Bunyan Hour, this year a unique river cruise, will take place Monday evening.

Wilson W. Wyatt, Lieutenant Governor of the Commonwealth of Kentucky, will present the official address at the FPRS Luncheon, Tuesday from 12:00 noon to 2:30 p.m.

Wednesday evening will feature the Official FPRS Banquet, which will be followed by dancing and entertainment.

Tours

Special tours in and nearby Louisville are planned for lady registrants. A brunch and entertainment will be held Monday at 10:30 a.m., and a special optional tour of the Bluegrass Area is scheduled for Thursday.

Seven plant tours have been confirmed, as described elsewhere in this issue, and the Ohio Valley Host Section will arrange for "custom tours" on request.

Lt. Governor Wilson W. Wyatt

TECHNICAL PROGRAM

MONDAY, JUNE 19

Session 1—Division 1—Anatomy & Fundamental Properties—"A"—1:30 p.m.–4:30 p.m.

Marra

Youngs

Program Chairman: A. A. Marra, School of Natural Resources, University of Michigan, Ann Arbor, Mich.

Session Chairman: R. L. Youngs, U. S. Forest Products Laboratory, Madison, Wis. "Low Stress Rheological Behavior of Wood" by Richard Pentoney and Robert Davidson, College of Forestry, State University of New York, Syracuse, N. Y.

"Quantitative Evaluation of Second-Order Drying Stresses" by A. P. Schniewind and P. C. Kersavage, University of California, Forest Products Laboratory, Richmond, Calif.

"The Internal Friction and Speed of Sound in Douglas-Fir as Affected by Temperature and Moisture Content" by W. L. James, U. S. Forest Products Laboratory, Madison, Wis.

Session 2—Division 7—Treatments & Coatings—1:30 p.m.–4:30 p.m.

Program Chairmen: Ralph H. Bescher, Koppers Co., Inc., Pittsburgh, Pa., and Ira Hatfield, Wood Treating Chemicals Co., St. Louis, Mo.

"Evaluation of Hot and Cold Solvent Technique for Extracting Creosote From

Wood" by T. W. Smeal, N. L. Wolfson, and W. W. Leach, Applied Research Laboratory, U. S. Steel Corp., Monroeville, Pa.

"Applications of the Gamma-Ray Backscatter Technique for the Inspection of Utility Poles" by W. E. Loos, Measurement & Controls Laboratory, Research Triangle Institute, Durham, N. C.

"A New Method of Using Liquefied Petroleum Gas to Pressure Impregnate Wood with Water-Repellent Penta" by D. W. Goodwin and R. E. Hug, Koppers Co., Inc., Pittsburgh, Pa.

"Accelerated Weathering of Red Oak with Various Preservatives Used to Treat Crossties" by R. C. Rietz, U. S. Forest Products Laboratory, Madison, Wis.

Session 3—Division 10—Production Management—1:30 p.m.–4:30 p.m.

Program and Session Chairman: J. J. Allegretti, Scott Lumber Co., Burney, Calif.

"Exterior Durability of Factory Primed Hardboard" by C. M. Winchester, Interchemical Corp., Cincinnati, Ohio.

"The Corporate Image of Furniture Manufacturing" by S. W. Freeman, Drexel Furniture Co., Drexel, N. C.

Panel discussion of Division objectives—preparatory to Division Business Meeting.

TUESDAY, JUNE 20

Session 4—Division 1—Anatomy & Fundamental Properties—"B"—8:45 a.m.–11:30 a.m.

Program Chairman: A. A. Marra, School of Natural Resources, University of Michigan, Ann Arbor, Mich.

Session Chairman: F. F. Wangaard, Yale School of Forestry, New Haven, Conn.

"The Architecture of Cellulose" by M. L. Rollins, V. W. Tripp, A. T. Moore and I. V. deGruy, Southern Regional Research Laboratory, U. S. Department of Agriculture, New Orleans, La.

Wangaard

Lewis

"Comparison Between Measured & Theoretical Drying Diffusion Co-efficients for Southern Pine" by A. J. Stamm and R. M. Nelson, Jr., School of Forestry, N. C. State College, Raleigh, N. C.

"Development of An Adequate Concept of Wood Quality for Guidance of Wood Technologists, Geneticists, and Forest Rangers" by H. L. Mitchell and M. Y. Pillow, U. S. Forest Products Laboratory, Madison, Wis.

Pillow

Mitchell

Haas

Dickstein

Session 5—Division 5—Particle & Fiber Processes—"A"—8:45 a.m.–11:30 a.m.

Program Chairman: W. C. Lewis, U. S. Forest Products Laboratory, Madison, Wis.

"Theoretical Determination of Optimum Properties for Particle Board" by E. L. Bryan, University of California, Forest Products Laboratory, Richmond, Calif.

"Molding Special Shapes from Wood Particle and Resin" by Herbert Haas, Werzalit–Pressholzwerk, Oberstenfeld bei Stuttgart, West Germany.

"The Detection and Significance of Free Formaldehyde in Particle Board" by John Dickstein, The Borden Chemical Co., New York, N. Y.

"Dimensional Stabilization of Reconstituted Wood Panels and an Accelerated Method for Measuring Linear Hygroexpansion" by W. A. Saums, The Crosset Co., Crosset, Ark., and H. Dale Turner, Masonite Corp., St. Charles, Ill.

"Particle Geometry, Its Effect on Resin Distribution and Dimensional Stability of Flake-Type Particle Board" by R. N. Jorgensen, Pennsylvania State University, University Park, Pa.

Session 6—Veneers & Plywood—(Sponsored jointly by Division 6—Glues & Gluing Processes, and Division 8—Drying)—8:45 a.m.–11:30 a.m.

Hale

Ripley

Program Chairman: H. R. Evans, Plywood Research Foundation, Tacoma, Wash.

"Variables Encountered in Commercial Veneer Drying and Correlation with Laboratory Studies" by T. F. Hale, Veneer Services, New Albany, Ind.

"The Gluing of Mountain Type Douglas Fir and Western Larch in the Manufacture of Plywood" by R. H. Ripley, Douglas Fir Plywood Assn., Tacoma, Wash.

"Pre-Pressing Plywood Assemblies" by A. L. Lambuth, Monsanto Chemical Co., Seattle, Wash.

WEDNESDAY, JUNE 21

Session 7—Division 5—Particle & Fiber Processes—"B"—8:45 a.m.–11:30 a.m.

Program Chairman: W. C. Lewis, U. S. Forest Products Laboratory, Madison, Wis.

"Use Practice for Particle Board" by R. E. Dougherty, National Particleboard Assn., Washington, D. C.

"Use Practice for Hardboard" by Walter Walling, (President—American Hardboard Assn.) Georgia–Pacific Corp., Seattle, Wash.

"The User of Fiber and Particle Panel Materials—What He Wants and Is Willing to Pay For"—Panel Discussion—Moderator: J. R. Roberts, U. S. Gypsum Co., Des Plaines, Ill.—Participants: T. Walter Noble, Decar Plastics, Inc., Middleton, Wis., and Willard Worth, National Homes Corp., Lafayette, Ind.

Session 8—Division 11—Marketing—8:45 a.m.–11:30 a.m.

Program Chairman: W. B. Lloyd, Michigan State University, East Lansing, Mich.

"Present and Future Markets for Wooden Pallet Products" by William Sardo, Jr., National Wooden Pallet Manufacturers Assn., Washington, D. C.

"Successful Selling" by John Reno, The Pacific Lumber Co., Chicago, Ill.

"The Marketing of Lumber and Forest Products to the Government" by A. M. Camarano, National Lumber Manufacturers Assn., Washington, D. C.

Carruthers

Hudson

Session 9—Division 8—Drying—"A"—8:45 a.m.–11:30 a.m.

Program Chairman: E. M. Conway, Conway Corp., Grand Rapids, Mich.

"The Variation in Moisture Content of Veneers Dried in a Mechanical Dryer" by Joseph F. S. Carruthers and R. W. Hudson, Forest Products Laboratory, Princes Risborough, England.

"Drying Stresses and Stress Relief in Thin Sections of Wood" by H. Kubler, Federal Research Station for Forestry and Forest Products, Reinbek, Germany. (Paper to be presented by J. F. Lutz, U. S. Forest Products Laboratory, Madison, Wis.)

"The Value of Presteaming for Drying Some Collapse-Susceptible Eucalypts" by G. S. Campbell, Commonwealth Scientific & Industrial Research Organization, South Melbourne, Australia. (Paper to be presented by R. Rietz, U. S. Forest Products Laboratory, Madison, Wis.)

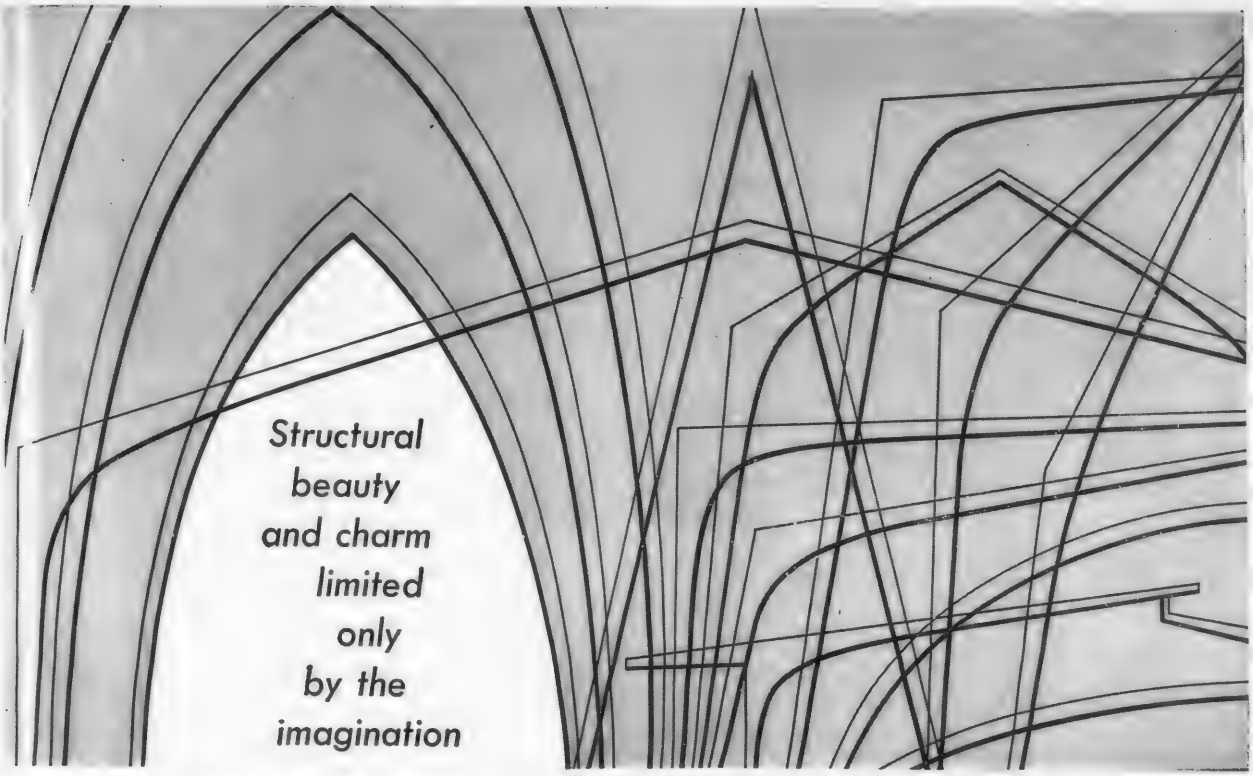
"The Effect of Thermal Degradation on Shrinkage and Collapse of Three Australian Species" by W. G. Kauman, Commonwealth Scientific & Industrial Research Organization, South Melbourne, Australia. (Paper to be presented by E. L. Ellwood, Univ. of Calif., Forest Products Laboratory, Richmond.)

"Research, Application and Experience in High Temperature Drying in Germany, by F. F. P. Kollmann, Munich, Germany.

"Shrinkage of Cell Walls and Cell Cavities in Thin Wood Sections" by E. L. Ellwood, University of California, Forest Products Laboratory, Richmond, Calif., and W. W. Wilcox, University of Wisconsin, Madison, Wis.

Wilcox

Ellwood



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Wooden arches, beams and trusses laminated with waterproof PENACOLITE resorcinol adhesives – for bonds stronger than the wood itself–offer the designer full freedom of expression. These glues allow wooden members to be easily shaped to any desired form in either traditional or contemporary design with many combinations and variations of the basic types . . . without losing inherent structural strength.

Economy of Laminated Wood Construction

Laminated wood is one of the most economical types of construction. It arrives at the job site already fabricated and cut to size for fast erection–resulting in reduced construction costs. In addition, laminated timbers with their natural color and beauty eliminate the need for costly concealing finishes.

PENACOLITE adhesives will retain their strength even under the most exacting temperatures, ranging from –40°C. to temperatures that char the wood–earning for laminated members favorable fire insurance rates.

Room Temperature Curing with PENACOLITE Adhesives

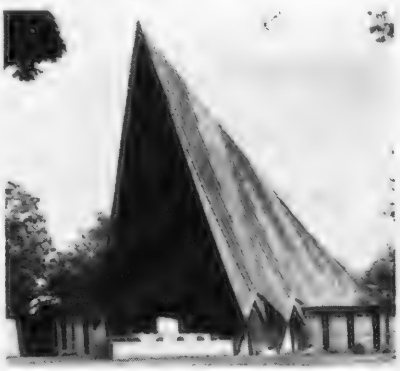
PENACOLITE adhesives are thermo-setting resins that cure easily at room temperature (70°F.). The curing process is irreversible–glues cannot be softened by further heating.

Write for the PENACOLITE Adhesives brochure, C-6-149, Koppers Company, Inc., Chemicals and Dyestuffs Division, Pittsburgh 19, Pennsylvania.

KOPPERS®

Photo, Unit Structures, Inc.

Carousel Theater, University of Tennessee–Penacolite adhesives bond these exposed timbers. Building octagon shaped. Arches–"V" type. Span–60'.



Photo, Unit Structures, Inc.

Church in Conover, N.C.– Bonding adhesives–Penacolite. Arch span varies from 37'3" to 97'10". Roof pitch varies per foot from 34-27/32" at one end to 4-5/8" at the other.

Photo, Unit Structures, Inc.

Dierks Forest Company Office Building, Hot Springs, Arkansas–Penacolite adhesives were used in this modern office building in laminated timbers.

"Seasoning Degrade Studies in Kiln-Drying Western Softwoods" by A. C. Knauss, Forest Products Consultant, Portland, Ore.

Session 10—Division 8—Drying—"B"—1:30 p.m.–4:30 p.m.

Program Chairman: E. M. Conway, Conway Corp., Grand Rapids, Mich.
Session Chairman: R. Millett, 146 Alymer Ave., Ottawa 1, Ontario.
"Distortions of Wood During Drying with and without Restraint" by W. C. Stevens, Forest Products Research Laboratory, Princes Risborough, England.
"Forced Air Drying of Lumber—Research and Commercial Operation" by T. W. Rucker, Dixon–Powdermaker Furniture Co., Jacksonville, Fla., and W. R. Smith, Southeastern Forest Experiment Station, Asheville, N. C.
"Seasoning Lumber to Meet Rigid Moisture Specifications" by D. E. Nelson, Conway Corp., Grand Rapids, Mich.
"Drying Lumber by Solar Heat" by E. C. Peck, U. S. Forest Products Laboratory, Madison, Wis.

Nelson

Peck

Session 11—Division 6—Glues & Gluing Processes—"A"—1:30 p.m.–4:30 p.m.

Program Chairman: C. B. Hemming, U. S. Plywood Corp., Brewster, N. Y.
"Geometry as an Independent Variable in Adhesive Joint Studies" by A. A. Marra, School of Natural Resources, Univ. of Mich., Ann Arbor, Mich.
"Cure Rates of Urea–Formaldehyde Resins as Evaluated by Two Rapid Test Methods" by G. Kitazawa and T. Duncan, The Borden Chemical Co., Philadelphia, Pa.
"The Effect of Bacteria and Mold Exposure on Six Selected Glues" by W. L. Day and G. F. Swenson, U. S. Plywood Corp., Brewster, N. Y.
"Reinforced Wood Laminated Beam" by A. Sliker, Michigan State University, East Lansing, Mich.

THURSDAY, JUNE 22

Session 12—Division 6—Glues & Gluing Processes—"B"—8:45 a.m.–11:30 a.m.

Blomquist

Hemming

Program Chairman: C. B. Hemming, U. S. Plywood Corp., Brewster, N. Y.
Session Chairman: R. Blomquist, U. S. Forest Products Laboratory, Madison, Wis.
"Control of Quality in the Fabrication of Glued Plywood Components" by R. M. Garret, Edward Hines Lumber Co., Chicago, Ill.
"High Strength Corner Joints for Wood" by B. Richards, School of Agriculture, Auburn University, Auburn, Ala.
"Glue Line Quality, How to Achieve and Control It"—Panel Discussion—Moderator: D. C. Dosker, Gamble Bros., Inc., Louisville, Ky.—Participants: C. McLagen, M. Rudhe, R. H. Ripley.

Session 13—Division 4—Chemical Conversion—"A"—8:45 a.m.–11:30 a.m.

Program Chairman: J. F. Saeman, U. S. Forest Products Laboratory, Madison, Wis.
Session Chairman: F. G. Perry, Jr., A. D. Little Co., Cambridge, Mass.

Wilkie

Anderson

"A Physico-Chemical Study of Wood Charcoal Produced in a Cinder Block Kiln" by T. H. Whitehead and R. W. Sherrill, University of Georgia, Athens, Ga.
"Comparison of Three Methods for Determining the pH of Wood & Paper" by A. J. Stamm, N. C. State College, Raleigh, N. C.
"Acetylation of Wood Thicker Than Veneer and the Dimensional Stability of Twelve Species of Acetylated Wood" by I. S. Goldstein, E. B. Jeroski, A. E. Lund, J. F. Nielson, and J. W. Weaver, Koppers Co., Inc., Verona, Pa.
"Solvent Drying of California Redwood" by W. B. Fearing, A. B. Anderson and C. R. Wilke, University of California, Forest Products Laboratory, Richmond, Calif.
"Outside Storage of Pine Pulp Chips Summer and Winter" by Joe Saucier and R. L. Miller, Georgia Forest Commission and Southeastern Forest Experiment Station, Asheville, N. C.

Session 14—Division 3—Mechanical Conversion—8:45 a.m.–11:30 a.m.

Keppler

Huxter

Program Chairmen: J. K. Barrow, Jr., Barrow Manufacturing Co., Ahoskie, N. C., and N. C. Franz, School of Natural Resources, University of Michigan, Ann Arbor, Mich.
"Machinability—Similarities and Contrasts of Woods and Metals" by L. V. Colwell, University of Michigan, Ann Arbor, Mich.
"Fundamental Wood Cutting Research at the New York State College of Forestry" by R. W. Perkins, State University College of Forestry, Syracuse University, Syracuse, New York.
"Effect of Resaws on Production and Performance of Circular Headrig Sawmills in the Black Hills," by E. F. Landt, South Dakota School of Mines, Rapid City, S. Dak.
"Costs—The Key to Sawmill Profit" by W. E. Keppler and W. T. Huxter, Wood Products Extension Section, School of Forestry, North Carolina State College, Raleigh, N. C.

Session 15—Division 4—Chemical Conversion—"B"—1:30 p.m.–4:30 p.m.

Saeman

Stranks

Program and Session Chairman: J. F. Saeman, U. S. Forest Products Laboratory, Madison, Wis.
"Studies on the Lignosulfonates of Birch Spent Sulfite Liquor" by I. A. Pearl and D. L. Beyer, Institute of Paper Chemistry, Appleton, Wis.
"Inorganic Constituents of Wood" by E. L. Ellis, University of Michigan, Ann Arbor, Mich.

Ellis

Locke

"Utilization of Aspen Wood Residue by Ruminococcus Flavefaciens" by D. W. Stranks, Forest Research Branch, Ottawa Forest Products Laboratory, Ottawa, Canada.
"Gas Chromatography for Tall Oil & Turpentine Analyses" by I. A. Stine and J. B. Doughty, West Va. Pulp & Paper Co., Charleston, S. C.
"Wood Saccacharification by the Hydrogen Chloride Gas Process" by Jun Kusana and Tadao Ishii, The Noguchi Institute, Tokyo, Japan.
"Working Party on Wood Hydrolysis, FAO Technical Panel on Wood Chemistry"—(A Review of the 1960 Tokyo Meeting) by E. G. Locke, U. S. Forest Products Laboratory, Madison, Wis., and Eric Garnum, Food & Agriculture Organization of the U. N., Rome, Italy.

Session 16—Division 2—Timber Production—1:30 p.m.–4:30 p.m.

Program Chairman: J. W. Lehman, Tennessee Valley Authority, Norris, Tenn.
"Separating Bark from Wood Chips" by J. M. Blackford, Hosmer Machine Co., Contoocook, N. H.
"Skidding on Rubber" by W. A. Turner, Union Bag—Camp Paper Corp., Franklin, Va.
"A Complete Pulpwood Harvesting System" by Thos. N. Busch, International Paper Co., Mobile, Ala.
"The Weight-Volume Relationship of Southern Yellow Pine Timber" by R. H. Page, Southeastern Forest Experiment Station, Asheville, N. C.

Page

Blackford

Abstracts of Selected National Meeting Papers

Nelson

Stamm

Comparison Between Measured and Theoretical Drying Diffusion Coefficients for Southern Pine

A. J. STAMM and R. M. NELSON, JR.
School of Forestry, North Carolina State College, Raleigh, N. C.

Experimental measurements were made of the rate of drying of small flat and edge grain specimens of southern pine sapwood in a forced convection oven. The specimens were weighed at appropriate intervals without removal from the oven. Measurements were made at temperatures ranging from 50° to 120° C. Experimental diffusion coefficients calculated from the data increased exponentially with an increase in temperature. Theoretical diffusion coefficients were calculated from a combination of the bound water and the water vapor diffusion coefficients through the wood together with values for the dimensions of the various component structures in series and parallel combination. These diffusion coefficients are shown to be in good agreement with the experimental values.

Seasoning Degrade Studies in Kiln-Drying Western Softwoods

A. C. KNAUSS
Forest Products Consultant, Portland, Ore.

This paper describes several studies made at lumber-producing mills equipped with modern, efficient dry-kilns in which the amount of degrade due to seasoning defects was measured, and its effects in reducing the sales realization of the lumber below its potential value was calculated. Ponderosa pine, Douglas-fir, and western hemlock are included. Lumber was graded in the rough green condition as it emerged from the sawmill, using the grade requirements for dry lumber. Then the lumber was kiln-dried and surfaced, after which it was again graded by the same rules. The ongrade lumber was tallied and the degraded lumber was also tallied together with the cause of the degrade.

In Ponderosa pine, 4/4 C Select showed 28 percent degrade, due chiefly to surface checking and warp, with a reduction in sales value of $22 per M. In Douglas-fir, 1 by 6 C&Btr. Finish, showed a degrade of 19 percent with a loss in sales value of $4 per M. The same item in western hemlock showed a degrade of 15 percent with a loss in sales value of $3.50 per M. Construction grades of lumber in these species are kiln-dried to higher moisture content levels—12 to 18 percent—to avoid serious degrade from planer splitting and damage to knots. Ponderosa pine, 1 by 12 no. 2 Common showed a degrade of 14 percent due principally to known damage, with a sales value loss of $5.50 per M. Douglas-fir, 2 by 12 Construction, showed a degrade of 14 percent with a loss in sales value of $1.50 per M. Western hemlock 2 by 10 Construction showed a degrade of 8 percent with a loss in sales value of $1 per M.

It is not possible to kiln-dry lumber without the development of some seasoning defect and resultant degrade. Degrade losses shown here are serious enough to warrant further examination of the kiln-drying schedule and operation to minimize the loss.

Knauss

Jorgensen

Effect of Particle Geometry and Resin Spread on Dimensional Stability of Oak Flake Board

R. N. JORGENSEN and R. L. ODELL
Pennsylvania State University, School of Forestry, University Park, Pa.

Samples were made from 16 different flake sizes in 4 different lengths and assembled using 3 different resin levels. In addition to the processing of the finished board, the flakes obtained from various stages in the manufacturing process were studied. All specimens were conditioned at 90° F. starting at 15 percent relative humidity and going through steps of 21, 50, 83, and 92 percent in adsorption and then back in desorption to an oven-dry condition. Percent thickness swell was calculated. The thickness swell plotted against specific gravity gives a straight line with a negative slope, whereas other studies have shown a positive slope. The thickness dimensional change occurring in relative humidities of 83 percent and above, or an equilibrium moisture content of between 14 and 20 percent, are the only significant changes in thickness dimension determined by statistical analysis. Both the flake thickness and resin spread have a significant effect on the thickness dimensional changes.

The combination of thin flakes and high resin spread results in a board having good thickness stability properties. No significant effect of flake length on dimensional stability was determined. Inverse results were found on e.m.c. by resin spread in that the equilibrium moisture content was increased by increases in resin spread while thickness changes were limited. Unassembled flakes which had received the resin treatment also equalized at a higher e.m.c. in adsorption than either the dried or freshly cut flakes.

A significant difference in the e.m.c. exists between the face and core positions of a panel in adsorption. This difference is not present on subsequent desorption. The loss of hygroscopicity due to high temperature platens is apparently recovered at 92 percent relative humidity but was not investigated sufficiently to be proven. The percent thickness changes and equilibrium moisture content relationship plotted on logrithmic coordinates is approximately a straight line.

Results are of value in that they indicate equilibrium moisture contents reached by various size particles and various resin spreads at controlled humidity conditions. The dimensional changes in adsorption and desorption are shown to be negligible up to 14 to 20 percent equilibrium moisture content. Dimensional changes beyond 83 percent relative humidity, at 90° F., are extreme, apparently due to complete release of internal forces inherent in the compressed mass of wood particles, known as springback.

Accelerated Weathering of Red Oak Treated With Various Preservatives Used to Treat Crossties

R. C. RIETZ
U. S. Forest Products Laboratory, Madison, Wis.

A study was conducted to determine if creosote- and pentachlorophenol-containing preservative solutions reacted differently in their tendency to retard surface checking of oak in an accelerated weathering test. Compared to untreated controls, all preservatives tested effectively reduced surface checking. No significant differences in surface checking were found among the various preservatives. Specimens cut from planks that were surfaced before drying surface-checked less in subsequent accelerated weathering than did the specimens cut from normal sawmill rough-cut planks.

Rietz

Garnum

Chemical Conversion of Wood in Japan

E. G. LOCKE and L. E. G. GARNUM
U. S. Forest Products Laboratory, Madison, Wis.; and FAO, Rome, Italy

The papers presented at the Second Meeting of the Working Party on Wood Hydrolysis, Food and Agriculture Organization of the United Nations, held

in Tokyo, Japan (1960) are briefly described. Several processes that are emerging as commercial methods for glucose production are summarized. The conclusion is that a new chemical wood conversion industry is developing in Japan. Although dextrose production is its primary aim, the industry is characterized by a wider use of wood components than its predecessors. Intense research is now being carried out on the utilization of chemicals derived from wood. This research may further develop relatively large units to produce a variety of chemical compounds and end-products which are now mainly derived from the petrochemical industry.

Kusama

Ishii

Wood Saccharification by Hydrogen Chloride Gas Process

J. KUSAMA and T. ISHII

Research Staff of New Japan Nitrogeneous Fertilizer Co., Ltd.; and the Research Division of the Minamata Factory, Ass't Prof. of Hokkaido Univ., Tokyo, Japan

Sawdust or wood particles reduced to the size of sawdust is prehydrolyzed in acid and separated from hemicellulose hydrolyzate,then washed and dried. The pretreated wood particles are impregnated with a small amount of concentrated hydrochloric acid, suspended in the high-speed flow of cooled hydrogen chloride gas, heated to complete hydrolysis, and further heated to a highed temperature to recover the acid.

The resultant reversion product is dextrose converted-dextrose in the post hydrolysis step. The crude sugar solution is deionized by the ion exchangers and decolorized by synthetic resin, followed by concentration and crystallization. The recovered acid and gas are recirculated directly to the steps of impregnation and adsorption.

The features of this saccharification are: 1) acid recovery is simple; 2) a short time is required; 3) equipment cost is reduced; 4) saccharification yield is about 90 percent; and 5) economical raw materials such as sawdust and hardwood are preferable; agricultural wastes such as bagasse, straw, and corncobs ar promising raw materials.

Forced Air Drying of Lumber—Research and Commercial Operation

T. W. RUCKER and W. R. SMITH

Dixon-Powdermaker Furniture Co., Jacksonville, Fla.; Southeastern Forest Experiment Station, Asheville, N. C.

Research results of the Forest Service tests at Athens, Ga., are compared with the commercial results obtained at Dixon-Powdermaker Furniture Company, Jacksonville, Fla.

Rucker

W. Smith

Since air movement is necessary to remove moisture, drying is proportional to the rate of air forced through the stacks up to 1,000 feet per minute. Speeds of 500 to 600 feet per minute are economical. The relative humidity of the air must be such that the air can absorb additional moisture. One thousand cubic feet of air at 40° F. and 100 percent relative humidity will contain approximately 0.40 pounds of moisture. Similarly, at 80° F. the capacity is approximately 1.65 pounds per moisture content feet; 4 times as much. By raising the temperature of fully saturated air at 60° F. to 70° F., relative humidity is decreased to approximately 70 percent.

Vapor pressure forces the movement of moisture from the core to the shell. Vapor pressure at 40° F. is 0.12 psi. Similarly, at 80° F. it is 0.51 psi. Thus, the force will be approximately 4 times as great.

Forced air drying is far better than uncontrolled air drying and results in monetary savings from reduced drying time, improved uniformity of drying, and practically eliminates many drying defects such as stain, warp, splits, and checks. Forced air is not a substitute for kiln drying when moisture content under from 10 to 15 percent is required.

Gamma-Ray Backscatter Technique Applied to Utility Poles

W. E. LOOS

Measurement and Controls Laboratory, Research Triangle Institute, Durham, N. C.

The gamma-ray backscatter technique is a rapid nondestructive method for the detection of internal defects in utility poles. This method makes use of the principle that gamma rays passing through a material are scattered by that material; when they are scattered, these gamma rays lose some of their energy. The number scattered generally is a function of the density of the material. Those that are scattered backward have an energy determined solely by their initial energy and independent of the scattering medium. This fact makes it possible to use pulse height selection of the backscattered gamma rays, thus improving the sensitivity of the backscattering technique. The recent development of transistorized pulse height selection circuitry now makes the construction of a portable field instrument feasible.

To determine from the many geometry factors those that are most germane to this backscattering technique, many factors were tested, such as source-detector distance, source depression, and detector depression. From several statistical studies on these variables, the optimal geometry conditions were obtained. Once optimal conditions were determined, scans of utility pole sections with known defects were made with the gamma-ray backscattering device. From these scans, it is apparent that the gamma-ray backscatter method may be used for detecting internal rot in utility poles.

Distortions of Wood During Drying With and Without Restraints

W. C. STEVENS

Forest Products Research Laboratory, Princes Risborough, England

As a result of differential shrinkage, ther is usually a tendency for wood to disto during drying. The manner in which diffe ent forms of distortion occur is explaine Twisting is mainly attributable to spiralit of the grain, and it has been deduced fro purely geometrical considerations, and con firmed experimentally, that the tendency t twist increases with an increase in the angl of spirality and decreases as the distanc from the pith is increased. Experimen have been made to find to what extent di tortion can be reduced by imposing re straint on the wood as it dries. The result show that if a sample is held flat and straight during drying, some distortion wil occur immediately the restraint is removed, and for a time thereafter there will be a gradual increase in the distortion before a steady shape is finally assumed. The ultimate distortion is, however, much less than that which occurs on matched material dried without restraint. It was found that restraint was more effective with beech *(Fagus sylratica)* than with African mahogany *(Khaya irorensis)*, more effective on green wood than on partially dry, and more effective at high temperatures than low. Cross-grain distortion could be reduced to a greater extent than longitudinal distortion.

It has been observed that planks of Sitka spruce *(Picea sitchensis)*, grown in Britain, always twist in the same direction although not by the same amount. With a view to taking advantage of this characteristic, experimental loads of these planks have been stacked for kiln drying on a base deliberately twisted in a direction opposite from that in which the planks would twist if dried freely. Steel joists were placed across the tops of the loads, and steel straps and telegraph screws were provided so that the loads could be tightly strapped to the base throughout the kiln treatment. The planks dried in this way had a final average twist of only 1.43 degrees whereas similar planks stacked for kilning in the normal way developed an average twist of 5.04 degrees.

The Internal Friction or Speed of Sound in Douglas-Fir as Affected by Temperature and Moisture Content

W. L. JAMES

U. S. Forest Products Laboratory, Madison, Wis.

The log decrement and natural frequency of free longitudinal vibration in Douglas-fir beams were measured over a temperature range of 0° to 200° F. and moisture content from about 2 to 27 percent. Specimens were 1⅞ by 1⅞ by 39½ inches, giving natural frequencies in the order of 2,500 cps. Natural frequency decreased both with increasing temperature and with increasing moisture content, but the log decrement showed minimums at certain temperature and moisture content combinations.

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RCI BUILDING, WHITE PLAINS, N. Y.

Outside Storage of Pine Pulp Chips

J. R. SAUCIER and R. L. MILLER
U. S. Forest Service, Southeastern Forest Experiment Station, and St. Regis Paper Company, Pensacola, Fla.

Two long-time experiments were conducted on the outside storage of pine pulp chips at Fargo, Georgia. The first pile was erected in May and observed for 5 months. The second pile was erected in December and observed for 12 months. Data were losses, obtained periodically on specific gravity losses, moisture contents, pulp yield and quality, and presence of stain and decay organisms. Weather data and pile-temperature data were also obtained. Conclusions indicate that losses for chips are approximately the same as for roundwood; hence, chip storage is recommended and suggestions are given for piling and handling chips to minimize losses.

Saucier

Whitehead

A Physico-Chemical Study of Wood Charcoals Produced in a Cinder

T. H. WHITEHEAD and R. W. SHERRILL
University of Georgia, Athens

The small producer cannot usually afford the expense of investing in equipment for activating his charcoal and must find a market for inactivated charcoal produced in kilns. This study reports work done on charcoals produced in cinder kilns in Georgia with oak wood and in Wisconsin with sugar maple wood without activation. Comparisons with commercial activated charcoals are made. The physical properties studied were sieve size, bulk density, and true density. The standard permanganate and iodine reactions were studied and analyses for carbon, hydrogen, oxygen, and ash were made. The pH of water extracts of each charcoal were determined and found to be alkaline in all cases, except pine which was slightly acidic (pH 6.0).

Adsorption and desorption isotherms at 0° C., 25° C., and 40° C. were made with each charcoal using liquids and gases. Liquids used were water solutions of sulfuric acid, sodium hydroxide, acetic acid, tetramethylammonium hydroxide, and liquid chloropicrin. Gases used were ammonia and methyl bromide. The kiln charcoals were comparatively inefficient in adsorbing odors or flavors (10 to 20 percent of commercial charcoals) in the order: oak, sugar maple, hardwood, and pine. They were even poorer in adsorbing colloids or color bodies. The charcoals varied from 10 to 80 percent efficiency compared with an activated wood charcoal in adsorbing organic acids or bases from water solutions. Oak was best and pine least in efficiency. However the kiln charcoals were comparable to the activated charcoal in adsorbing inorganic acids and bases from water solution. The kiln charcoals were 30 to 50 percent efficient in adsorbing gases from gaseous media as compared with cocoanut charcoal of commerce. The desorption rates of gases from kiln charcoals were much faster than from commercial activated charcoals as would be expected.

Busch

Stine

A Complete Pulpwood Harvesting System

T. N. BUSCH
International Paper Co., Southern Kraft Division, Mobile, Ala.

The pulp and paper industry is numbered among the five foremost industries in the United States. In spite of the fact that pulpwood represents the major cost of a ton of pulp, its production and harvesting has received scant attention. Any system, regardless of how it is employed, must be applicable to extensive areas, conditions, and circumstances of mill yard layouts, stand densities, topography, and rapid relocations. It must have a productivity factor commensurate to capital investment, higher rates of pay to the crews, and hold the line on the delivered cost of a cord of pulpwood. This paper and an accompanying film will describe a complete system of mechanized logging predicated on the idea that machinery must be tailored to do the job without resorting to expendiencies. The equipment is so designed and employed that each machine functions as an entity without split-second timing.

Gas Chromatography for Tall Oil and Turpentine Analyses

I. A. STINE and J. B. DOUGHTY
West Virginia Pulp and Paper Co., Research Laboratory, Charleston, N. C.

Gas chromatography greatly facilitates the assay of tall oil acids for investigation and plant control work. Oleic, linoleic, linolenic, stearic, and palmitic acids are the more dominant of the common fatty acids, while the whole may range from acids containing from 9 to 23 carbon atoms in their chain. Some typical analyses are given along with data on many pure acids used for reference. The utility of gas chromatography in routine turpentine assay is also described.

Reinforced Wood Laminated Beam

A. SLIKER
Department of Forest Products, Michigan State University, East Lansing, Mich.

A discussion is presented of wood laminated beams assembled with aluminum sheet stock inserted between selected layers. Finished beam dimensions were 7 feet by 5 inches by 5 2/3 inches. Load deflection data and strain data were recorded for both horizontal and vertical orientations, and types of failures were observed. In addition, results were compared with theoretical information.

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Reno

Bryan

Optimum Properties of Particle Board

E. L. BRYAN
California Forest Products Laboratory

Efforts are continually being made to improve particle board by alteration of particle geometry, resin content and methods of application, by modification of press schedules, and by experiments with many other factors that have an effect on the strength and related properties of the material. However, all of this is done without knowing what maximum values could be obtained if all pertinent factors were held at the best possible level. Although advancements can be made without such knowledge, research development could be held more easily in proper perspective if the existent physical limitations of the material are known. This investigation was undertaken to define the optimum values that can be expected for certain properties from considerations of wood species, board density, layer composition, and particle orientation. The study treats flexural strength, tensile strength parallel and perpendicular to the face, and dimensional stability. The results are expressed in terms of the thickness of the surface layers, the board density, the degree of particle orientation, and the basic properties of the wood material used. Applications of the results to boards presently produced show that optimum properties are closely approached in some cases.

Gluing of Mountain Type Douglas-Fir and Western Larch in the Manufacture of Plywood

R. H. RIPLEY
Douglas Fir Plywood Association, Aacoma, Wash.

A laboratory gluing experiment with veneers cut from Rocky Mountain Douglas-fir and western latch using typical adhesives of interior and exterior type shows that both species can be successfully glued following accepted plywood plant gluing procedures. The experiment included three drying conditions (oil, gas, and steam dryers), two spread levels, two assembly times and five glues. Satisfactory performance was achieved with all glues at normal assembly times. Veneer from both oil and gas dryers was not satisfactorily glued.

Comparison of Three Methods for Determining the pH of Wood and Paper

A. J. STAMM
School of Forestry, North Carolina State College, Raleigh, N. C.

Thin cross sections of four different softwoods and four different hardwoods and multiple thicknesses of four different papers weighing approximately 4 gm. each were soaked in 25 ml. of distilled water and in 25 ml. of unbuffered dilute solutions of sodium hydroxide and of hydrochloric acid having pH values ranging from 2 to 12. The pH of the solutions were determined after various periods of contact with the samples using a new pressure type of glass electrode, and surface contact pH values was measured on the specimens after their removal from the distilled water. The pH values obtained, in pure distilled water, on the surface of the specimens removed from the distilled water, and from the intercept of the plot of the equilibrium pH of the various unbuffered solutions against their original pH with the line representing equal original and equilibrium pH values were compared. The values determined in these three different ways agree when the specimens are allowed to soak for at least half an hour before making the measurements. The plots show that both wood and paper exhibit a significant buffering action upon the solutions that increases in degree with time and varies appreciably among the different samples.

FPRS SECTION MEMBERSHIP GOALS

Wanted: 300 New Members by June 1, 1961

Section	New V. & A. Members Section Goal	Percent of Goal Attained	Membership Chairman
Midwest	30	80	R. C. Newstedt
Ohio Valley	10	80	H. E. Cook
Great Lakes	20	50	N. C. Franz
Upper Mississippi Valley	10	20	L. A. Ropella
Mid-South	25	132	H. L. Russell
Northeast	50	56	R. F. West
Eastern Canadian	20	100	Alfred Glennie
Carolinas-Chesapeake	25	100	Alfred Glennie
Southeastern	10	120	P. J. Bois
Pacific Northwest	50	52	Tom McKenna
Inland Empire	10	60	R. L. McNett
Northern California	20	70	Victor Roth
Rocky Mountain	10	60	R. S. Bader
Pacific Southwest	10	130	W. E. Ripley, Jr.

As of May 1, an overall total of 75 percent of the membership goal has been attained. Five chairmen have met or exceeded their goals. H. L. Russell, Mid-South, is high with 132 percent. W. E. Ripley, Jr., Pacific Southwest, follows closely with 130 percent. Walton R. Smith, National Membership Chairman, will announce the final results at the Annual Meeting in Louisville, Ky.

If it's a question about wood preservatives...

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Controls ugly blue-black sap stains and mold. Keeps lumber bright and clear . . . stops costly degrading. Contains no arsenic or mercury—non-irritating and dustless—resists leaching from rain.

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WOOD TREATING

Candidates for FPRS Executive Board

D. K. Saunders

T. S. Veazey

In accordance with the FPRS Constitution, National and Regional Nominating Committees recently announced candidates for the Society's Executive Offices. The slate of candidates will be presented by ballot to the membership at large, and the results of the election will be announced at the Society's 15th Annual Meeting in Louisville, Ky., Monday, June 19.

Donald K. Saunders, current President-elect, will automatically become President in June, succeeding Raymond H. Berry, vice president and general manager of Scott Lumber Co., Burney, Calif. Mr. Berry will remain on the Executive Board as Past President.

Saunders, president and chairman of the board of Saunders Brothers, Westbrook, Maine, has been active in FPRS for more than 10 years. He has been Chairman of the Northeast Section, Northeast Regional Board Member, Division Coordinator, and General Chairman of the 14th Annual Meeting in Montreal, Canada in 1960. He is now serving as Technical Program Chairman for the Louisville meeting.

T. S. Veazey, The Anaconda Co., Bonner, Montana, and current FPRS Vice President, has been nominated President-elect. A Montana School of Mines graduate, Veazey has served FPRS as Pacific Northwest Regional Board Member, Division Coordinator, and National Membership Chairman.

J. J. Allegretti

J. L. Love

Four candidates have been nominated for Vice President. They are Joseph J. Allegretti, James L. Love, Fred E. Dickinson and H. O. Fleischer. Dickinson and Fleischer were nominated by petition in accordance with FPRS Constitution, Article VIII, Section 6.

Joseph Allegretti, director of the Special Products Division of Scott Lumber Co., Inc., Burney, Calif., is a charter member of FPRS and has been active in the Society since its inception. He was one of the organizers of the Upper Mississippi Valley Section, and he served as chairman of the Midwest Section. He was North-Central Regional Board Member from June 1958 to June 1960, when he resigned because change of employment required him to leave the region. A graduate of the University of Idaho, Allegretti was associated with Masonite Corporation for 14 years before he joined Scott Lumber Co., Inc.

James L. Love, president and general manager of Love Wood Products Co. and president of Miramul Co., makers of soil conditioners from wood residues, has been a member of FPRS since 1947, the year of its inception, and he is a charter member of the Mid-South Section. Elected as South Central Regional Board Member in 1959 and appointed Chairman of the Budget and Finance Committee, Love has worked closely with the National Office in the past year to establish the Society's new accounting system. A graduate of Louisiana State University, Love was a leading influence in the selection of New Orleans as the site for the 1963 Annual Meeting, and he is now working on preconvention arrangements.

F. E. Dickinson

H. O. Fleischer

Fred E. Dickinson, Director of the University of California Forest Products Laboratory, Richmond, Calif., is a charter member of FPRS and a past chairman of the Northeast Section. In 1951, Dr. Dickinson served on the program committee for the Fifth Annual Meeting. He was general chairman of the 1954 Annual Meeting at Grand Rapids, Mich., and publicity chairman for the 1959 Meeting at San Francisco. Elected to the Executive Board as the Southwest Regional Board Member in 1958, Dr. Dickinson is now chairman of the Society's standing committee on Public Relations. A native of Minnesota, he holds degrees from the University of Minnesota, Michigan State University, and Yale.

Herbert O. Fleischer, Chief, Division of Timber Processing, U.S. Forest Products Laboratory, Madison, Wis., has been a member of FPRS since 1948. A past chairman of former FPRS Division of Veneers and Plywood, Dr. Fleischer served as a member of the committee that prepared the recommendations for the reorganization of the Society's product-oriented divisions to process-oriented divisions. Dr. Fleischer holds degrees from the University of Michigan and Yale University. He is currently serving as Chairman of the Publications Committee and is a member of the Midwest Section.

A. F. Muschler

Regional Board Members

The Southwest Regional Nominating Committee has selected MacGregor Graham, 1952 Wright Ave., Richmond, Calif., as candidate for Southwest Board Member to succeed F. E. Dickinson, whose term of office expires this year.

Graham, Vice-President of Tim-Co, Inc., has been in the timber fabricating business for 25 years, and is recognized as having introduced glulam into Northern California. A graduate of the University of California at Berkeley, Graham is a member of the Structural Engineers Association of Northern California.

The North-Central Regional Nominating Committee has nominated Arthur F. Muschler, Technical Director of the Edward Hines Lumber Co., Chicago, Ill., as Regional Board Member. Muschler has been acting board member since June 1960 when he was appointed by the Executive Board to fill the post vacated by J. J. Allegretti's resignation.

Muschler has been a member of FPRS since 1948. Before his Board appointment in 1960, he was a member of the committee that reorganized the Society's division srtucture. He has an MF degree in wood technology from Yale University, and he has completed additional graduate work at the University of Michigan and at the Swiss National Technical Institute, Zurich, Swizerland.

From 1950–1953 he served as instructor on the staff of the School of Forestry, Yale University. He joined the Edward Hines Lumber Co. in 1953.

1962 Nominating Committee

In accordance with the FPRS Constitution, the following nine men have been nominated as candidates for the National Nominating Committee: R. H. Bescher, Koppers Co., Inc., Pittsburgh, Pa.; R. E. Blomquist, U. S. Forest Products Laboratory, Madison, Wis.; J. A. Hauter, Allan Products Co., Oradell, N. J.; G. M. Hill, Drexel Furniture Co., Drexel, N. C.; R. L. Hiller, American Cyanamid Co., Chicago, Ill., H. B. McKean, Potlatch Forests, Inc., Lewiston, Id.; A. Mottet, Long-Bell Division, International Paper Co., Longview, Wash.; W. R. Warner, Bradley Southern Division, Potlatch Forests, Inc., Warren, Ark., and R. W. Wellwood, Faculty of Forestry, University of British Columbia, Vancouver, B. C., Canada.

The four men elected from this group by the membership at large, and the two immediate past presidents not serving on the Board, shall constitute the 1962 National Nominating Committee.

National Meeting Committee At Work

Left to right: Carl Trinkle, General Chairman, The Baldwin Piano Company, Cincinnati, Ohio; Roy Westenfelder; Harold Moser; Charles Hill, Publicity Committee, General Plywood Corp., Louisville, Ky.; and (back to camera) Hal Cook, Committee Vice Chairman, The Masonite Company, Jeffersonville, Ind.

Left to right: Roy Westenfelder, Paul Bunyan Chairman, The Carborundum Company, Indianapolis, Ind.; Harold Moser, Finance Chairman, Gamble Bros., Louisville, Ky.; Charles Hill, Publicity Committee, General Plywood Corp., Louisville, Ky.

Left to right: Charles Dieckmann, Local Arrangements Committee, Smith Cabinet Company, Salem, Ind.; Robert Allen, Local Arrangements Chairman, National Casein Company, New Albany, Ind.; Mel Balgeman, The Borden Company, New Albany, Ind.; and Hal Cook.

Barrow Lumber Company, Ahoskie, N.C., a Southern Pine Mill Mater "42" Riderless Carriage and Mater Bar Turner

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SECTIONS in the NEWS

Northeast: A joint meeting of the Maine Forest Products Council and a district meeting of the Northeast Section was held April 28 in Hallowell, Maine. Speakers included Harold Moulton, National Lumber Manufacturers Association; Winfred Hibbard, Passamaquoddy Lumber Co.; F. C. Simmons, Northeastern Forest Experiment Station; Paul Graham, Clinic of Wood; and F. T. Parrish, Heywood-Wakefield Co. Annual meeting for the Northeast Section is scheduled November 2–3 at the Hotel Prince George, N. Y., N. Y., according to Ronald Gale, Secretary-Treasurer.

Pacific Southwest: J. H. Layman, vice-chairman, reports that a one-day meeting was held May 24th in Los Angeles. Subjects covered included light-weight core materials and logging in Southern Calif. Speakers included Herman Stumpf, Verticel Pacific Co., Joe Slapnik, Koppers Co., Inc.; and C. W. Vallette, Big Bear Timber Co.

Carolinas-Chesapeake: Thirty-four members and guests attended a one-night dinner meeting in Washington, D. C., April 17. Ray Osborne, Tariff Commission, Washington D. C. served as program chairman. John Zerbe, National Lumber Manufacturers Assn. made the local arrangements. Speakers included Gerald Prange, NLMA Wood Promotion Program and W. R. Smith Regional Board Member and FPRS National Membership Chairman.

Upper Mississippi Valley: A one-day meeting on "Wood Fabrication" was held at the Wausau Club in Wausau, Wis., April 28. Section Chairman L. A. Ropella was panel moderator. Participants included: R. Christofferson, Conner Lumber and Land Co., Laona, Wis.; Frank Maly, Vulcan Corporation, Antigo, Wis.; E. J. Driscoll, Crestline Co., Wausau, Wis.; H. Moon, Protection Products Co., Kalamazoo, Mich.; and Brad Hoffman, Viking at Wausau, Wausau, Wis. Next UMV Section meeting is scheduled for Sept. 22, at the Research Laboratories of the Minnesota Mining and Manufacturing Co., St. Paul, Minn. Theme of the meeting is "Adhesives and Coatings for the Future." Details will be announced in the next issue.

Pacific Northwest: Medford, Oregon was the scene of a two-day meeting May 8–9. Speakers at the two technical sessions included: D. J. Miller, Oregon Forest Research Center, Corvallis; Carl Rasmussen, Western Pine Assn., Portland; C. A. Newport, Pacific Northwest Forest & Range Experiment Station, Portland; and F. C. Ratliff, Crown Zellerbach Corp., Gamas, Wash. The second session featured: G. F. Hoeber and Dr. Lawrence Leney, Institute of Forest Products, Seattle; Dr. B. F. Cooper, Oregon State University, Corvallis; and R. W. Kennedy, University of British Columbia, Vancouver, B. C. Banquet speaker was Glen Jackson, California Oregon Power Co., who discussed high-lift helicopters for logging. Fall meeting of the section is scheduled for Victoria, B. C. Dates will be confirmed soon, reports R. W. Pettersen, PNW Secretary.

Southeastern: John R. Hamilton, Secretary-Treasurer, reports that Southeastern Section members are active in the Southern Wood Seasoning Association. SWSA officers elected at an April 20 meeting in Montgomery, Ala., included: president, Don Post, University of Florida; vice president, John Stewart, Macon, Ga.; and secretary-treasurer, Paul Bois, Macon, Ga. Bois is also Southeastern membership chairman. Dr. Allyn M. Herrick, Southeastern Chairman, announces the next Section meeting will be in Florida sometime in December. Exact time and location have not been confirmed.

Inland Empire: Spring meeting was held April 11–12 at Spokane, Washington (See May *Journal*). J. P. Howe, Section Secretary, reports the fall meeting will be held at Washington State University, Pullman, Wash., October 27–28.

Mid-South: Annual meeting is scheduled for October 11–12–13, at the King Edward Hotel, Jackson, Miss., according to R. T. Clapp, Secretary-Treasurer.

Great Lakes: Secretary George Tasker reports a highly successful meeting was held May 25–26 at Midland, Mich. The meeting included technical sessions on acrylic coatings, adhesives, urethane foams, and water-repellent preservatives. Henry Huber, Dow Chemical Co., was program chairman. Speakers included Dr. R. H. Boundy, Robert Lalk, Dr. Turner Alfrey, Dr. E. C. Galloway, and L. I. Weinbrenner.

Northern California Elects New Officers for 1961–62

The following men were elected as officers of the Northern California Section at the spring meeting in Berkeley, Calif., April 20–21.

Chairman—Victor S. Roth, Triangle Lumber Co., Kensington, Calif.; Vice-chairman—Eric L. Ellwood, University of California Forest Products Laboratory, Richmond; Secretary-treasurer—William A. Dost, California Redwood Association, Hayward, Calif.; Membership Chairman—Collins Orton, Orton Machine Co., San Francisco; and Trustee—Kirk Cooper, The Weyerhaeuser Co., Arcata. Victor H. Clausen, Simpson Redwood Co., is past chairman.

FPRS 1963 Meeting Booked For New Orleans, Week of June 9

At an executive conference of the Mid-South Section of FPRS in New Orleans, April 7th, representatives of all states that comprise the Section adopted the week of June 9 as the best available date for the 17th Annual Meeting of the Society in New Orleans in 1963.

Section Chairman John Squires appointed a three-man committee consisting of James Love, Don Fassnacht, and William Hopkins to select a convention chairman. The Roosevelt Hotel was selected as FPRS convention headquarters.

In other business, it was decided to hold the annual meeting of the Mid-South Section in Jackson, Miss., October 11–12–13, preceding the Mississippi Forestry Days.

Theme of the meeting will be "Too Many Trees?" Program chairman will be DeVere Dierks, Jr., assisted by W. [illegible] Hopkins and Don Fassnacht. Plans also call for a forest products machinery and equipment exposition.

Those in attendance were: Chairman John Squires, Vice Chairman DeVere Dierks, Jr., Sec-Treasurer Robert T. Clapp, Trustee Joe C. Denman, William C. Hopkins, Dave Fisher, J. F. Haskins, Carlton Smith, Membership Chairman Harry L. Russell, Texas Membership Chairman Paul Kramer, Regional Representative Jim Love, Harold Davis and James Van Horn of the Dixie Lumberman & Forester, Jackson, Miss., Don Fassnacht and Charles Lockhard of the U. S. Forest Service, John Lehmann of Tennessee Valley Authority, and Charles Lanham of Lanham Hardwood Flooring Co., Louisville, Ky.

Seven Plant Tours Confirmed Plus Custom Tours On Request

John Young, Oliver Machine Co., New Albany, Ind., plant tours chairman for FPRS 15th Annual Meeting in Louisville, reports that wood-working companies in and near the Louisville metropolitan area have responded with a resounding "Welcome to FPRS Registrants."

In addition to tours to the seven plants listed below, Young announced recently that special tours would be arranged to any near-by concern. "If four or five members or guests express an interest in any particular plant, we will have members of the Ohio Valley Host Section arrange a custom tour and furnish transportation," he said.

At present, tours are planned to the following companies:

Chester B. Stem Co., New Albany, Ind., manufacturers of fine veneers and holders of one of the world's finest collections of rare woods.

Hoosier Panel Co., New Albany, Ind., producers of dimension plywood with fine faces veneers for the furniture industry.

Smith Cabinet Co., Salem, Ind., manufacturers of television cabinets and children's furniture.

Kroehler Manufacturing Co., Louisville, Ky., one of the world's largest furniture manufacturers.

Blue Grass Cooperage Co., Louisville, Ky., a company that utilizes the latest methods of production automation in the fabrication of oak barrels.

Gamble Brothers, Louisville, Ky., producers of precision wood parts and specialty laminates.

Wood Mosaic Co., Louisville, Ky., one of the nation's leading manufacturers of hardwood parquet flooring and fine quality veneers.

OBITUARY NOTICES

A. R. Tegge, Jr., Quartermaster Food & Container Institute, Chicago, Ill., died April 12 after a brief illness. A member of FPRS for more than 10 years, Tegge was well known throughout the industry for his work in packaging and containers.

Giovanni Colucci, founder of Southern Box & Lumber Co., Wilmington, N. C., died April 29. He served as company president for many years. His son, John Colucci, Jr., is now chairman of Carolina Pacific Plywood, Inc., also of Wilmington.

Peter A. Solem, president of Solem Machine Co., and the Merritt-Solem Division of Rockford, Ill., died April 28 in Rockford. Solem was considered a "dean of wood working machinery designers."

NAMES in the NEWS

Benar E. Welch has recently joined the staff of the American Institute of Timber Construction Inspection Bureau as inspector. Mr. Welch was previously with the Western Pine Association Research Laboratory for almost 8 years.

Robert S. Cockroft and **William S. Cockroft** opened their own business in Memphis, Tenn., in February. They will sell hardwood lumber, plywood, veneer, and dimension.

E. P. Skralskis has been named executive vice-president in charge of all OMARK Industries, Inc., operations within the United States, and **H. G. Cutright** was appointed to the staff position of vice president for marketing. OMARK is a timber cutting equipment and building equipment manufacturing firm.

United States Plywood board of directors has elected **M. K. Peterson** vice president of marketing administration, and **J. D. Kayne,** vice president of branch administration. Both are newly created posts. Mr. Peterson has been with U. S. Plywood since 1946, and Mr. Kayne since 1941.

J. A. Vaughan, Director of Research for Southern Wood Preserving Company, Atlanta, Ga., will retire on July 5, 1961. He is the author of numerous papers on wood preservation and related subjects and holds a number of patents in these fields, and may be available, after retirement, for consultation in matters pertaining to wood preservation.

Arthur Kreager has been appointed Owatonna Tool Co. (Minneapolis, Minn.) District Sales Manager for West Virginia and Western Pennsylvania. He was previously associated with the Upson–Walton Co., Cleveland.

Parker O. Anderson will retire June 30 after 36 years as a member of the University of Minnesota (St. Paul) staff. He has served as extension forester at the University since 1925, and has devoted himself to promoting constructive forestry and conservation practices. He received 1960 Senior Forester of the Year award from Keep Minnesota Green, Inc., and he was honored recently by Central States Extension Foresters for his educational work.

Dr. John S. Boyce, Jr., forest pathologist, will join the University of Georgia's Department of Plant Pathology and Plant Breeding July 1. Dr. Boyce has been with the Southeastern Forest Experiment Station, Asheville, N. C., for the past 11 years.

Guy E. Sabin has been named general sales manager for OMARK Industries, Inc., Portland Ore. He was previously sales manager for OMARK's Fastening Division.

Percy Tonk, chairman of the board, Tonk Manufacturing Co., has resigned as treasurer of the National Association of Furniture Manufacturers after 14 years of service. Named as the new treasurer is **Jerry Metz,** president, J. L. Metz Furniture Co., Inc., Hammond, Ind.

James W. York, Largo, Fla., has become field representative in Florida for the Protection Products Mfg. Co., Kalamazoo, Mich. He has been in the Building Industry for almost 10 years, the last 5 of which were with the National Gypsum Co.

Earl R. Schafer, Madison, Wis., has retired from his post at the U. S. Forest Products Laboratory there. He spent nearly 40 years at the Laboratory conducting research on various aspects of plup and paper production. His early research dealt with the making of paper from seed flax straw, a material now widely used for making cigarette paper and lightweight Bible paper.

The Franklin Glue Company, Columbus, Ohio announces the addition of Mr. Robert C. Gill to its staff. Prior to this association, Mr. Gill was in charge of wood adhesives development and technical service for the Peter Cooper Corporations, Gowanda, N. Y.

BLACK BROTHERS GLUE SPREADERS

Complete Range of Sizes and Types for Fast, Economical, Accurate Gluing

No. 22-D HOODED GLUE SPREADER — The modified 22-D glue spreader is arranged to successfully apply contact cements and adhesives containing volatile solvents. 8" through 122" capacities in 6" increments. *Bulletin 11-A, Part 5.*

No. 22-D GLUE SPREADER — For resins, caseins, polyvinyls, protein and similar adhesives. 39 sizes in four models, 8" through 122" capacities in 6" increments. Proven the finest spreader available for the purpose. *Bulletin 11-A, Part 4.*

No. S67 GLUE SPREADER — Floor type, power-driven, hand feed roll glue spreader for edge gluing and similar operations. 12", 18" and 24" roll widths with 8½" diam. rolls. *Bulletin 11-A, Part 2.*

No. 2-B BENCH-TYPE GLUE SPREADER — For light edge gluing and similar operations. Roll is 4" diam. x 8" long. *Bulletin 11-A, Part 1.*

VERTICAL GLUE SPREADER — Especially designed to speed edge gluing, eliminates need to turn stock 90 deg. after it comes out of sizing machine. Glues stock up to 4" thick.

"BOBTAIL" 22-D GLUE SPREADER — For efficient application of resin glues, equally adaptable for other solid glues. Ideal for edge gluing lumber stock or other applications which require bottom coating only. *Bulletin 11-A, Part 3.*

You'll never know how fast, accurate and clean a gluing operation can be 'til you put a Black Brothers glue spreader to work in your glue room. Black's complete line of economical high production glue spreaders contains models for practically every type of adhesive, stock and gluing operation: Single and double glue spreaders from 8" to 122" capacity — vertical, hopper-fed, conveyorized, etc. Models, from our bench-type spreaders for laboratory or light production work — to our No. 22-D Super Series for extremely heavy duty operations. Of course, every Black's spreader has the extra-value features which have made them the leading name in gluing equipment throughout the world. Get full details today by writing for product bulletins.

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FROM THE COVER

Meet Donald K. Saunders, FPRS 15th President

A GREEK SCHOLAR in the lumber business. A student of the classics now concerned with production efficiency and automation. A soft-spoken man, yet able to drive his point home. A fair-minded man, yet firm in his own convictions. A dedicated man, devoted to the best interests of the Forest Products Research Society.

This is Donald K. Saunders, president and chairman of the board of Saunders Brothers, Westbrook, Maine, and the next president of the Forest Products Research Society.

Don joined the Society in 1950, the same year he became president of Saunders Brothers, a third-generation company founded more than 60 years ago and now one of the largest manufacturers of dowels in the country. He has served the Society hard and well in a variety of offices and committee duties since he became a member. He has served as trustee, vice chairman, and chairman of the Northeast Section. He was elected to the Executive Board in 1957, and served as chairman of the finance committee for the Buffalo meeting.

He became vice president of the Society at the San Francisco meeting in 1959, and was general chairman of the highly successful meeting in Montreal, Canada, in 1960. This year, he has been in charge of the first technical program to be conducted under the new process-oriented divisions.

A graduate of Dartmouth, Don joined his family company in 1935. Now president and chairman of the board, he says that it is his philosophy to be constantly dissatisfied, because from dissatisfaction comes the stimulus to seek improvement.

This, too, was one of his prime reasons for joining FPRS. "We were a small family company grown to the point where we needed professional management and where it was imperative to improve production, efficiency and utilization. FPRS has helped us do just that," he said.

Saunders was also active in the founding of the recently organized Maine Forest Products Council, and is now president of this organization, which is aimed at maintaining a cohesive voice for individuals and organizations interested in growing, processing, or marketing products of Maine forests. His personal hobbies are skiing, photography, music, and travel.

A STORY FOR THE LADIES . . .

"Where the Bluegrass is Greenest"

One morning last spring, a rather bedraggled young couple turned up at the homeplace of the most famous thoroughbred horse of all time, Man o' War. Ushered into the mellow, antique-furnished office at Man o' War Farms, they explained their mission.

They were Australians, they said, making their way around the world on a very limited budget. They had walked the nine miles from Lexington in a driving rain; the budget couldn't spare carfare. But they simply had to see where the storied Big Red had lived and died and founded a racehorse dynasty.

The young Aussies thoroughly enjoyed their stay, touring the immaculate barns and stables, strolling over springy wet bluegrass to the heroic statue of the great horse, sitting on the office's burnt-orange leather sofas and soaking up the heritage of the years—pewter mugs, julep cups, an ancient hunting horn, an 1848 map of the United States, a Brewer portrait of Man o' War.

Even after years of welcoming hundreds of thousands of unpredictable travelers to their premises, the horse-farm owners can't fully explain the irresistible lure of their estates. Nowhere, probably, is the traveling public received so readily on private property. The farms have nothing to sell; there are no concessions, no admission fees.

Whether the thoroughbred nursery be a business or avocation, the horse is the thing to the owner, of course. Bloodlines, breeding theories, training practices, racing forms are paramount. The Derby is *the* Derby. But beneath it all, in almost every case, you find a man or woman who loves the land.

This is the fabled Blue Grass, rolling and green and studded with great oaks and elms and maples.

The story above was published in MONSANTO Magazine in May (Vol. XLI, No. 2). It is reprinted here in part with the hope that its warm tone will say "welcome" to all FPRS ladies, and that it will encourage them to take advantage of the optional Bluegrass Tour. In addition to the fabulous thoroughbred horse farms, the tour will include historic Bardstown and other scenic areas.

COMING EVENTS

June 18–22: Annual Meeting, Forest Products Research Society, Kentucky Hotel, Louisville, Ky.

★

June 20–22: Annual Meeting, National American Wholesale Lumber Assn., Hotel Mark Hopkins, San Francisco, Calif.

★

June 21–22: June Meeting, Northern Hardwood and Pine Manufacturers Assn., Land O'Lakes, Wis., or Duluth, Minn.

★

June 21–27: Summer Program Planning Sessions, Building Research Institute, Wianno, Mass.

★

July 2–4: 15th Annual Meeting, National Wooden Pallet Mfrs. Assn., Chateau Lake Louise, Lake Louise, Alberta, Canada.

★

July 17–19: Annual Meeting, Philippine Mahogany Association, Inc., Harvest House, Boulder, Colo.

★

July 30–Aug. 2: Sixteenth Annual Meeting, Soil Conservation Society of America, Purdue University campus, West Lafayette, Ind.

★

Aug. 1: Summer Meeting, Ponderosa Pine Woodwork, Fairmont Hotel, San Francisco, Calif.

★

Aug. 2: Summer Meeting, National Woodwork Manufacturers Association, Fairmont Hotel, San Francisco, Calif.

★

Sept. 13–14: Northern Hardwood and Pine Manufacturers Assn., Northland Hotel, Green Bay, Wis.

★

Sept. 13–15: Semi-annual Meetings, Western Pine Association, Multnomah Hotel, Portland, Ore.

★

Sept. 14–16: Annual Meeting, 16th Annual Lake States Logging Congress, Timber Producers Assn., Green Bay, Wis.

★

Sept. 16–19: Annual Convention, National Assn. Furniture Mfrs., Hilton Hotel, Chicago, Ill.

★

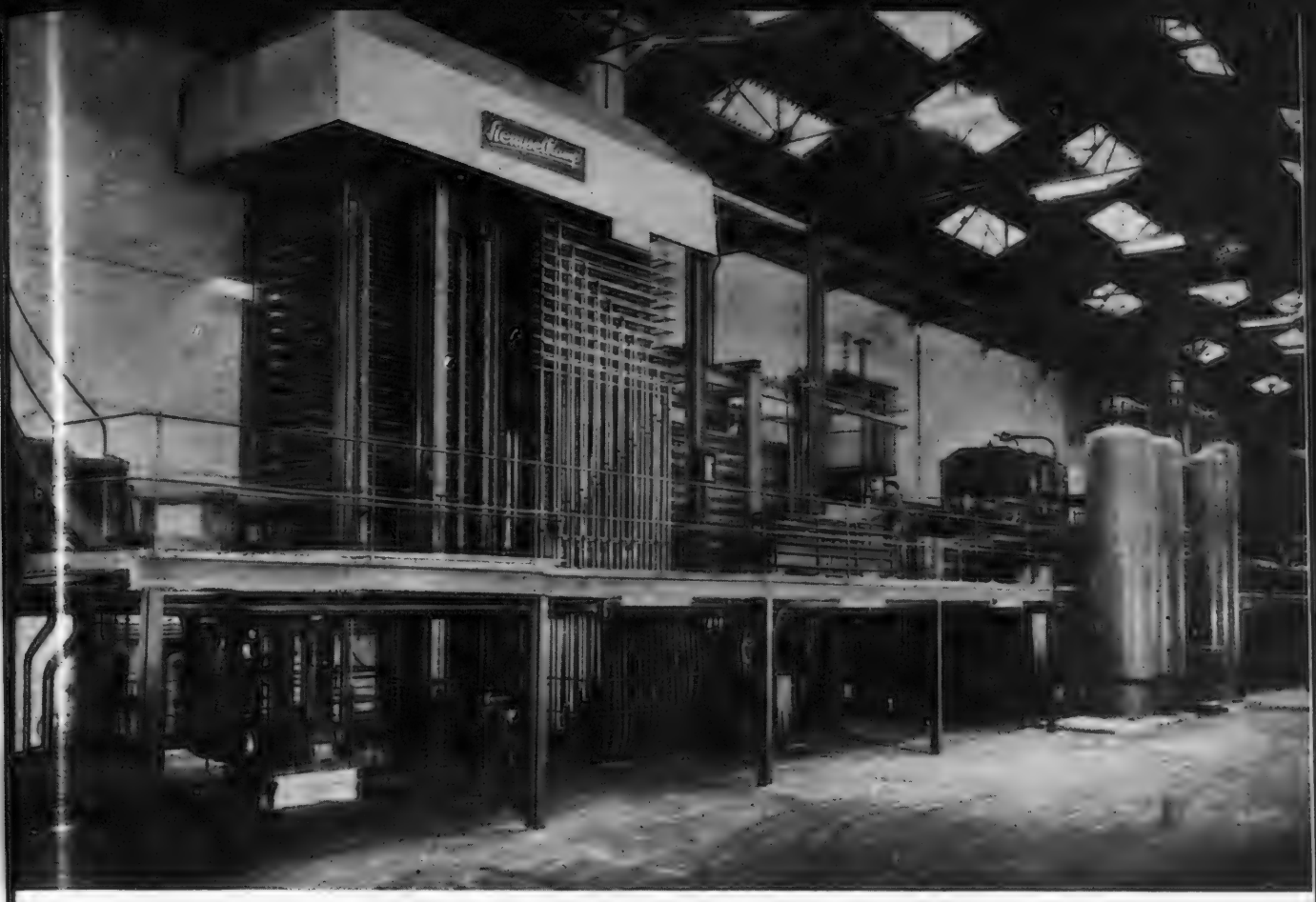
Sept. 17–20: Annual Convention, International Concatenated Order of Hoo-Hoo, Hotel Americana, Miami Beach, Fla.

★

Sept. 22: FPRS Upper Mississippi Valley Fall Meeting, Research Center, Minnesota Mining & Manufacturing Co., St. Paul Minn.

★

Oct. 11–13: FPRS Mid-South Section Meeting, King Edward Hotel, Jackson, Miss.



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NEW PRODUCTS and Literature

New Junior Brad Gun

A new Duo-Fast Junior Brad Gun, Model B–6032, is now available from the manufacturer, Fastener Corp., Franklin Park, Ill. It will drive brads flush, or countersink them 1/16 inch. It is a lightweight, compact tool which can be operated either with the conventional trigger or by a touch-trip mechanism. It is air operated, and can be powered by a small portable compressor or plant compressed air systems. More information may be obtained.

Circle Item 14

Combination Coater

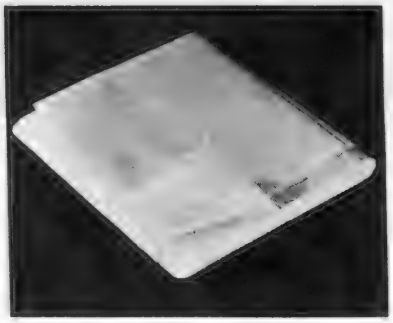
A 300 percent production increase in finishing kitchen cabinet doors was made possible at the United Cabinet Corp., Celestine, Ind., by the installation of a combination precision coater and double roller coater manufactured by Duboise Machine Co., Jasper, Ind. The combination coater applies precision stain and two coats of sealer in one operation. It was installed recently in order to overcome a bottleneck in door finishing which was hampering scheduled production increases. The precision coater also gives a depth and uniformity in the stain application that could not be duplicated with the previous method, spraying NGR stain.

Circle Item 15

Split-Level Houses

Although the popular split-level style of house offers many advantages, it also has certain disadvantages says the University of Illinois Small Homes Council-Building Research Council in a new publication. For the particulars, the new illustrated circular, "Split-Level Houses," may be written for. The circulars are free until August, 1961, and after that date, the price will be 15 cents.

Circle Item 16



Waterproof Blanket

A new, disposable waterproof blanket is being introduced by Busse Hospital Disposables, at a cost of 15¢ each. It is 40 inches by 72 inches and consists of several plies of white insulating cellulose backed by a soft, tough polyethylene plastic. It is suggested for use by highway patrols where the injured might require warmth on the ground. Since the manufacturer suggests it can be used under as well as over the patient. The blanket would also prove handy for use in camps and temporary shelters. Details and samples will be supplied upon request.

Circle Item 17

Natural Wood Finishes

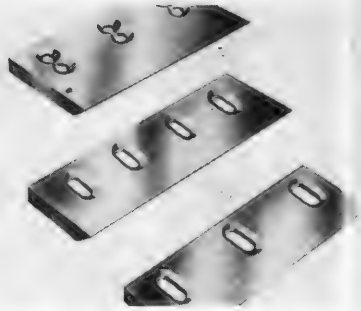
The development of two new natural wood finishes, Rezite-XX and Super Satinwood REZ, has been announced by REZ Wood-Tones, Inc., Springdale, Pa. Rezite-XX was developed as a clear exterior wood finish and is designed to produce a protective gloss film over bare wood for a natural effect. Super Satinwood REZ is a clear interior, low luster Polyurethane wood finish, and dries to a tough durable sheen in 20 minutes.

Circle Item 18

Automatic Polishing Machine

The new Model S–101 Automatic Polishing Machine, announced by Yates–American, Beloit, Wis., is a high production machine designed to produce superior finishes on sheet-type materials. It is especially applicable for finish white wood sanding, sealer and filler coat sanding, and polish sanding. Sanding drums are made of abrasive impregnated nylon. Selected grade of abrasive, variable oscillating motion of the drum, and adjustable feed rate provide the conditions for desirable finishes.

Circle Item 19



Chipper Knife for Sawmills

A special chipper knife, made by the Ohio Knife Company, Cincinnati, Ohio, is especially suited to the requirements of sawmill operation. It is a modification of the chipper knife used in the pulp and paper industry, and is being used more and more to dispose of waste slabs and small logs. In many cases, these special chippers are almost completely replacing old hog knives. Complete information may be requested.

Circle Item 20

Hardboard Booklet

"The Story of Hardboard," from forest to end-uses in the home and industry, is told in a 16-page illustrated booklet published by the American Hardboard Association in cooperation with American Forest Products Industries, Inc. The booklet, 3 years in the making, was designed as an instructional tool for high school and college students interested in forestry and conservation, as well as for the general public. Included in the booklet are basic definitions of hardboard and such key concepts as the American tree-farm system. The origin of hardboard is explained. Copies are available free.

Circle Item 21

Land and Water Investments

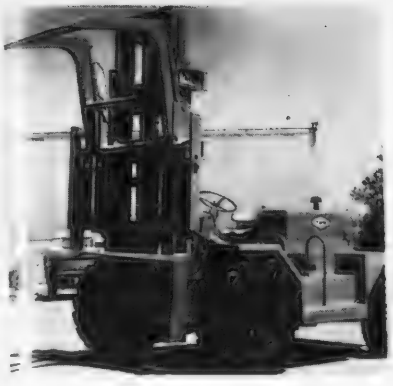
Your Investments in Land and Water, by Marion Clawson and Irving K. Fox has been added to the Resources for the Future reprint series. It is booklet No. 27, and was reprinted from *American Forests*, January and February issues, 1961. Single copies are free upon request. Additional copies are 25¢.

Circle Item 22

New Power Saw

A new concept in chainsaws is the PM 270 Canadien, Power Machinery Limited, Vaucouver, B. C., which is a fast and powerful direct drive saw that is designed and built solely for the professional woodsman. The saw was introduced to the market only in March and is already in demand in such places as Australia and Finland. It is a culmination of years of study, months of planning by Canada's foremost experts in chainsaw design. It is built in such a way that it can be serviced, when need be, by any mechanic using standard tools.

Circle Item 23



Fork Lift Trucks

Taylor Machine Works, Louisville, Mississippi, announces the expansion of their line of Yardster fork lift trucks with the introduction of the new Y–10W Yardster. This is a compact fork lift with wide axle steering and a load capacity of 10,000 pounds. It has many practical engineering features and operates on muddy or sandy log yards as well as improved yards. Big drive wheel tires and proper engineered weight distribution provide excellent traction because even when the Y–10W is not loaded, 56% of the total weight is on the drive wheels. More information may be obtained upon request.

Circle Item 24

Electric Drill

Many new design innovations are incorporated in a ¼-inch electric drill which has been introduced by the Disston Division of the H. K. Porter Company, Inc. The drill, called the "Dirk," operates in extremely close quarters, and it has the three-ampere motor at right angles to the drilling axis. From an operational standpoint, one of the biggest advantages is the large hand grip which permits the operator to hold it with all four fingers and a thumb. The drilling axis is in a direct line with the natural application of pressure.

Circle Item 25

Lumber Industry Facts

The 1960–1961 Edition of *Lumber Industry Facts* is a 56-page statistical handbook of historical and current information compiled from many sources. It provides statistics on the manufacture and distribution of lumber and wood products, and the role of the lumber industry in the national economy. It is available without charge, but the supply is limited.

Circle Item 26

Cooling Saws

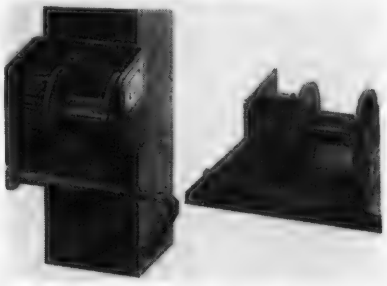
A new special large heavy-duty refrigerated mist collant spray method for cooling slitter saws, gang saws, and resaws has been announced by Lloyd Tool Corp., Pasadena, Calif. It is reputed to be more effective in cooling cutting tools than the old conventional flood coolant method. It is a portable system, and the principles utilized in producing this cooling are well known and basically and scientifically sound. The heat is absorbed by the expansion of compressed air and evaporation of minute liquid particles which are dissipated by the circulation of air. Complete information is available free without obligation.

Circle Item 27

New Sawmill on Wheels

The Northeast Ohio Machine Builders, Inc., Columbiana, Ohio announces a completely integrated, diesel-powered sawmill on wheels. Its capacity allows converting up to 1,200 board feet, into 1-inch cants per hour, from logs up to 36 inches in diameter by 20-foot lengths. It has a 16-foot, 4 headblock, sawmill carriage, circular saw husk, diesel power unit, hydraulic feed, conveyor and 3-saw edger and is transported on a rugged steel trailer. More information in the form of a brochure may be obtained.

Circle Item 28



Worm Gear Winch

A new high strength, compact worm gear winch for easily holding, raising, or lowering suspended loads up to one-half ton in any position desired, has been introduced by Thern Manufacturing Company of Winona, Minn. The special feature of the Model 46605 is an extra strong machine cut gear made from heat-treated ductile iron. It has a tensile strength of 100,000 pounds per square inch. The drum is one-piece cast iron construction and is joined to the gear by a new flange and slot method rather than being welded. Shafts, base, and handle are all made of steel. More information may be written for.

Circle Item 29

Gluing Flush Doors

A special sheet containing technical information on their 3530P casein glue for flush door gluing has been published by National Casein Company, Chicago, Ill. It also contains recommendations to door manufacturers for planning of door gluing lines. Available upon request.

Circle Item 30

What's New in *Technical Publications*

Single Copies of the Following Reports are Available Free Upon Request from the Director, U.S. Forest Products Laboratory, Madison 5, Wis.

Ten new or revised reports describing research results were published recently by the U. S. Forest Products Laboratory.

Two reports contain information of interest to the pulping industry. Results of pulping and papermaking experiments at the Forest Products Laboratory on various species of wood, plants, and fibers from Asian and Australasian countries are discussed in **Report 2211, "Pulping of Asian and Australasian Wood and Plant Fibers."** In **Report 2212, "Characterization of Sawdust and Shavings for Pulp,"** is information on particle size and fiber length of typical commercial sawdusts and shavings that are suitable for the manufacture of pulp.

A comparison of wood preservatives is given in two separate progress reports for 1961. In **Report 1757, "Comparison of Wood Preservatives in Mississippi Post Study,"** are data on the service life of southern pine test posts at two installations, one with 20 to 24 years of service and the other with 11½ years of service. Wood preservatives used on test stakes of southern yellow pine sapwood in six different sites are compared in a report entitled **"Comparison of Wood Preservatives in Stake Tests," No. 1761.**

Persons concerned with timber appraisals who often find it necessary to estimate lumber recovery of hardwood logs scaled by the International ¼-inch log rule as well as the Scribner Decimal C log rule will find **Report 2214** of considerable value in their everyday computations. Entitled **"Overrun Estimates of the Scribner Decimal C Log Rule and the International ¼-Inch Log Rule for Hardwood Logs,"** the report contains a comparison of the overrun values of the two systems by species, log grade, and log soundness.

In Report 2208, "Calibration of Electric Moisture Meters for Jack and Red Pine, Black Spruce, Paper Birch, Black Ash, Eastern Hemlock, and Bigtooth Aspen," are results of experiments to determine the species corrections, previously unavailable, for resistance and power-loss types of moisture meters when used on these seven American species.

Four reports in the Foreign Woods Series were revised to incorporate recent data on the physical and mechanical properties of the respective species. Two West African woods are described in **Report 1905, "Avodire," and in Report 2024, "Agba,"** while two species from South America are represented in **Report 1996, "Corisa," and in Report 1915, "Ishpingo."**

FPRS Fifteenth National Meeting

Timetable of Events

June 18–22, 1961
Louisville, Kentucky

SUNDAY, JUNE 18

1:00–8:00 p.m.
Registration

9:00 a.m.
Membership Committee Breakfast Meeting

12:00–5:00 p.m.
Executive Board Luncheon & Meeting

3:00–5:00 p.m.
Education Committee Meeting
Employment Committee Meeting
Publications Committee Meeting
Tellers' Committee Meeting

6:30–7:30 p.m.
Hospitality Hour

MONDAY, JUNE 19

8:00 a.m.–5:00 p.m.
Registration

7:00–8:30 a.m.
Authors' Breakfast

9:00–10:00 a.m.
General Session
Keynote Address
Presentation of Hitchcock Award
Presentation of Wood & Wood Products Awards

10:00–12:00 a.m.
15th Annual Business Meeting

10:30 a.m.–1:00 p.m.
Ladies Brunch & Entertainment

1:30–4:30 p.m.
Technical Sessions
I Anatomy & Fundamental Properties (A)
II Treatments & Coatings
III Production Management

6:30 p.m.
Paul Bunyan Cruise

TUESDAY, JUNE 20

8:00 a.m.–5:00 p.m.
Registration

7:00–8:30 a.m.
Authors' Breakfast

8:40–11:30 a.m.
Technical Sessions
IV Anatomy & Fundamental Properties (B)
V Particle & Fiber Processes (A)
VI Veneers & Plywood (Sponsored) by Divisions 6 and 8)

12:00–2:30 p.m.
FPRS Official Luncheon

2:45–4:15 p.m.
Business Meetings, Divisions 1 through 5
Business Meetings, Divisions 6 through 11

6:30–9:00 p.m.
Past Presidents' Dinner

7:30–9:30 p.m.
Section Officers Advisory Committee
Division Officers Advisory Committee

9:00 p.m.
Policy Committee Meeting

WEDNESDAY, JUNE 21

8:00 a.m.–4:00 p.m.
Registration

7:00–8:30 a.m.
Authors' Breakfast

7:00–8:30 a.m.
Publications Committee Breakfast

8:45–11:30 a.m.
Technical Sessions
VII Particle & Fiber Processes (B)
VIII Marketing
IX Drying (A)

10:00 a.m.–3:00 p.m.
Ladies Tour of Louisville

12:00–1:30 p.m.
Executive Board-Section Officers' Luncheon

1:30–4:30 p.m.
Technical Sessions
X Drying (B)
XI Glues & Gluing Processes (A)

Special Meeting Bark Mulch Standardization

7:30 p.m.
Official FPRS Banquet

THURSDAY, JUNE 22

8:00 a.m.
Registration

7:00–8:30 a.m.
Authors' Breakfast

8:00 a.m.–5:00 p.m.
Executive Board Breakfast & Meeting

8:45–11:30 a.m.
Technical Sessions
XII Glues & Gluing Processes (B)
XIII Chemical Conversion (A)
XIV Mechanical Conversion

9:00 a.m.
Ladies Blue Grass Tour & Luncheon (Optional $10 Ea.)

12:00–1:30 p.m.
Executive Board-Division Officers' Luncheon

1:30–4:30 p.m.
Technical Sessions
XV Chemical Conversion (B)
XVI Timber Production

p.m. Plant Tours:
Chester B. Stem Co.
Hoosier Panel Co.
Smith Cabinet Co.
Kroehler Mfg. Co.
Blue Grass Cooperage Co.
Gamble Bros., Inc.
Wood Mosaic Co.

FPRS FOREST PRODUCTS JOURNAL
VOL. XI, NO. 6
JUNE, 1961

Plywood in the Sixties[1]

MALCOLM K. PETERSON
United States Plywood, New York City

The author reviews the history of the plywood industry and looks forward to dynamic changes within the industry. He stresses continual basis research in the areas of processes and manufacture, and emphasizes other factors that will have profound effect on future marketing efforts.

DELTA FRAME BUILDING COMPONENT perfected by Douglas Fir Plywood Association. Distance from ground to ridge is 25 feet; distance from wing-tip to wing-tip is 82 feet; box beams are 16 feet on center; roofed area is 40 feet. (Photo courtesy DFPA.)

THE FUTURE OF PLYWOOD for the most part is a harvest of seeds sown in the past. There are basic needs evident in today's market place that have triggered the initial phases of research and marketing projects in plywood which should reach fruition in the next 10 years. I am convinced that we stand on the threshold of many spectacular technological innovations in the plywood industry.

Review

Prior to the prophecy of what lies ahead, I feel I should briefly summarize the progress of our industry to date. The rise of plywood is one of the most dramatic and significant chapters in the history of American industry. During the last 14 years, our gross national product has increased at a rate of 3.9 percent annually, and for a corresponding period, softwood plywood has more than tripled this growth pattern. Little more than a novel idea during World War I, it has now become an industrial giant. In the 10-year period from 1949 to 1959, softwood plywood alone recorded an amazing 330 percent increase, from 1.8 billion square feet to 7.8 billion square feet. Two or three decades ago, plywood was largely an experimental material with a narrow range of specialty applications. Today it is a standard material for a wide variety of construction and industrial uses. To exemplify the ever-increasing popularity of plywood, particularly in the construction industry, it is interesting to note that plywood usage per new house start has increased from a mere 400 square feet in 1950 to an estimated 2,600 square feet in 1960.

With this heritage of growth serving as our jumping-off point, where is plywood going during the Sixties? Market research analysts predict that by 1970 our annual consumption of softwood plywood will increase from a present 7.8 billion square feet to over 13.0 billion square feet. Our consumption of hardwood plywood, both from foreign and domestic sources, will rise from its present 2.1 billion square feet to 3.9 billion square feet.

The motivational economic force behind these optimistic projections is, of course, people. In a recently published forecast, it was estimated that the population is now growing at well over 3 million per year. At present rates, it is expected to reach 195 million by 1965, 214 million by 1970. These figures by themselves do not fully reveal the economic impact that the forthcoming population boom will bring. Economists predict that during the Sixties, about 16 million new non-farm dwelling units will be required—population growth alone will require 11 million, minimum replacement rate will require another 3 million, and a trend toward two-house families will call for 1 million more. An additional million units will be required to maintain the vacancy rate. It is estimated that the dollar volume of residential building alone will increase from the $23.3 billion in 1959 to $31.1 billion in 1969. This projection indicates an increase of 33 percent in physical vol-

The Author: M. K. Peterson has a B.A. from Lawrence in economics, and is a graduate of Harvard Business School. He was manager of the Boston territory and Northeastern Division Manager prior to his present position as director of merchandising for U. S. Plywood Corp.

[1] Presented at the fall meeting of the Northeast Section, Forest Products Research Society, at Yale University, New Haven, Conn., Oct. 14–15, 1960. Approved for publication Feb. 1961.

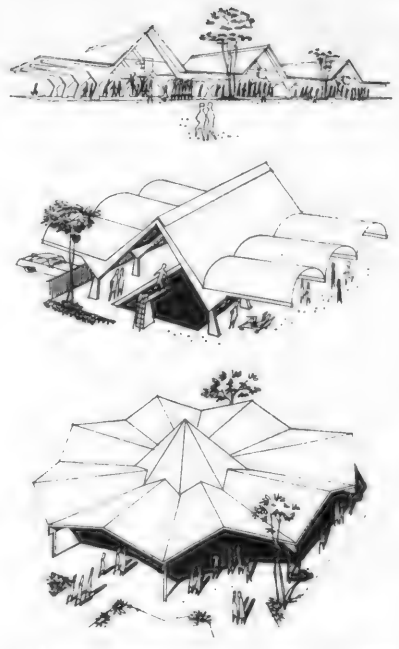
ume of residential building for the decade ahead. Spending for new dwelling units will rise 31 percent, 34 percent for additions and alterations, and 88 percent for non-housekeeping units in this 10-year period. The total construction market could conceivably reach $150 billion by 1970.

From the foregoing, it would appear that the plywood industry's future is as bright as a presidential aspirant's smile. However, the population explosion alone will not automatically guarantee golden years for everyone who is connected with the plywood industry. Certainly if we rest on past laurels we cannot help but garner a few gold medals, but to hold and increase our traditional markets as well as develop new ones against the encroachment of such rival materials as plastic and aluminum, we must look to our industry's research facilities for the technological advances that will keep plywood products pre-eminent in the market place.

Research

At the present time, research in the plywood industry, which will supply the developments of the Sixties, can be broken down into two general areas. The first is the research program of individual companies, which tends to be directed toward the development of new product specialties. My own company, for example, is engaged, in our laboratory facilities at the Lawrence Ottinger Research Center, in basic research to create new or improved products to employ wood wastes, new finishes and coatings, fire retardant chemicals, new adhesive methods, better wood color stabilization, and other structural materials in conjunction with plywood.

The second research area is geared to problems inherent in the basic area of plywood manufacture. The bulk of the effort here is undertaken by the manufacturers through the research facilities of the Douglas Fir Plywood Association. This latter effort is a continuous one which, over a period of years, has accumulated a broad basic technical knowledge of the properties of softwood plywood. To date, research is concentrated in three categories.

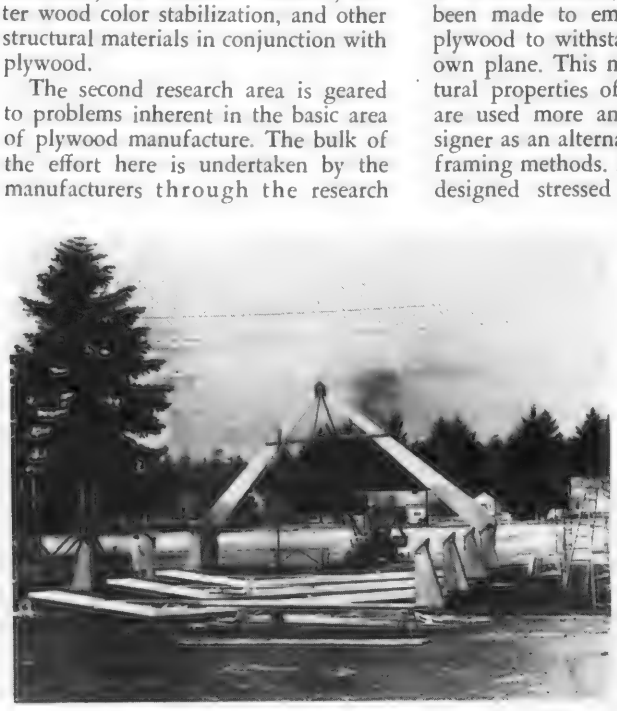


BY COMBINING DELTA FRAMES with other plywood components, a whole family of buildings can be created. Frames could be arranged in a triangle or in a circle to produce a variety of imaginative buildings.

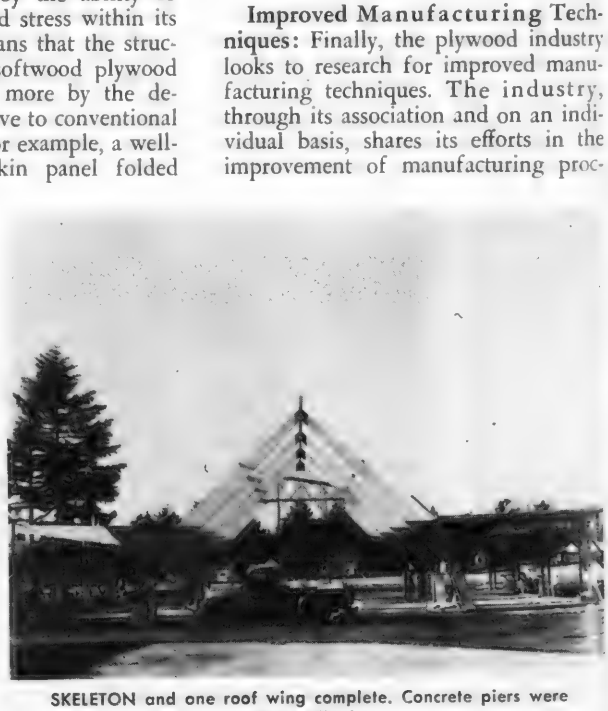
Structural Research: In the area of structural research, much progress has been made to employ the ability of plywood to withstand stress within its own plane. This means that the structural properties of softwood plywood are used more and more by the designer as an alternative to conventional framing methods. For example, a well-designed stressed skin panel folded plate roof structure eliminates as much as 70 percent of the conventional framing system that might otherwise be required. Another example is the development and refinement in design of the basic concept of the plywood box beam or the structural member to utilize plywood webs within the context of an I-beam structure. Here, engineers approach maximum utilization of the ability of plywood to withstand stress within its own plane. From this realm of structural technology will come the products and techniques that will enable the plywood industry to keep pace with the coming age of prefabrication.

Improved Plywood Surface Treatment: The rather unsatisfactory face which softwood plywood presents for conventional paint coatings and paint systems, together with the relatively soft and uneven properties of the standard grade of softwood plywood, has always presented a stumbling block to plywood marketing. During the past 15 years, most research directed toward surface treatment has been concerned primarily with the improvement of painted surfaces. Today the industry is awakening to the possibility of various types of plastic surfaces. During this decade, many new types of plastic resin, Neoprene base, and metallic surfaces for softwood plywood will be developed. These new surface treatments promise a double-barreled benefit to the plywood industry. They will eliminate costly job site finishing problems and meet the challenge of the so-called "maintenance-free" construction materials.

Improved Manufacturing Techniques: Finally, the plywood industry looks to research for improved manufacturing techniques. The industry, through its association and on an individual basis, shares its efforts in the improvement of manufacturing proc-



PROTOTYPE of delta frame structure was created for school playground.



SKELETON and one roof wing complete. Concrete piers were intentionally low.

esses. There are several operational breakthroughs that we look for in the years ahead.

Reduce Labor: First, machinery and manufacturing processes should be developed to reduce the tremendous labor factor in plywood. Despite refinements in the production process, plywood is still manufactured in essentially the same way it was 25 years ago. Obviously there is tremendous room for improvement here, and this decade is apt to witness startling changes.

Lower-Grade Logs: Utilization of lower grade logs must be increased to permit better husbanding of our timber resources. Today manufacturers are making excellent construction grade plywood and sheathing from logs previously thought unfit for plywood. At the same time, very substantial research has resulted in new grading rules, making it possible to employ up to 50 percent of the white pocket infected timber found primarily in the old-growth areas of southern Oregon. New structural data should see a much heavier usage of softwood species other than Douglas-fir. For example, Western larch or tamarack already has been processed in a new manufacturing facility in Missoula, Montana. Plywood manufactured from this material has been recognized as equivalent in strength to fir panels. It is now possible, by adjustments in panel construction, to interchange hemlock and most true firs (except *Abies concolor*) with Douglas-fir plywood in structural application.

Gluing Techniques: Finally, new gluing techniques will be developed. Foamed glues already show some promise in achieving more even spread at lower cost. Dry sheet adhesives are also promising, in that they could considerably simplify the process of manufacture. Perhaps the most significant technological advance feasible in the Sixties would be the adoption of a standardized exterior glue line for all plywood manufacture. This bold stroke would eliminate the necessity of marketing both exterior and interior panels.

Projection Summary

To sum up the Sixties from a research standpoint, we see in the years to come the utilization of plywood in fanciful roof shapes and domes. There will be heavy use of large building components with plywood as the basic material. Painting problems will be eliminated to a large extent by the development and refinement of both hard and flexible plastic coatings, serving as factory-applied surfaces over plywood for exterior wall sheathing in commercial and residential building, and the marriage of plywood with other building materials through the magic of new bonding techniques. Finally, much more efficient utilization of available raw material will develop during the decade, and substantial improvements in the manufacturing process will take place, reducing the high labor factor in plywood production.

In the preceding discussion of plywood's future, I have devoted the preponderance of my remarks to the impact of plywood research on the future of our industry. I have stressed research because of its extreme importance. However, I would like to mention briefly two other factors which will have a profound effect on the future marketing efforts of the plywood industry.

We are aware of the wide price fluctuation with which the plywood industry is afflicted. Plywood consumption is subject to extreme peaks and valleys, caused both by the winter doldrums in the building cycle and the vagaries of the housing industry. In the production of plywood, the industry has consistently ignored these changing demand patterns and maintained a uniform production rate, regardless of market conditions. Thus we continually find ourselves with either a scarcity or an over-supply. The recent voluntary production curtailment in the face of a fall-off in housing starts indicates that manufacturing maturity can be expected in the Sixties with the expected corollary of stable prices. In addition, the trend toward plywood's production concentrated in the hands of several large manufacturers cannot help but put an end to the roller-coaster price problems that have marked plywood's adolescence. This tendency toward consolidation will also result in a forward integration from the tree to the ultimate consumer. Today plywood reaches the construction site in a variety of ways, and the distribution systems employed are studied constantly to single out the most effective method to control the entire marketing structure. The Sixties could very well see a few major plywood companies completely integrated from the forest to not only the retail outlet but also to the company-owned land development and construction company.

This decade is indeed one of change and choice. The possibilities are unlimited and the stakes high. Plywood's share of the construction dollar hinges upon the fruition of our research efforts. We confidently expect to see more definite advances in plywood technology in the next ten years than we have known in our industry's history prior to 1960.

New Delta Frame Component Perfected by DFPA

Typical of the research efforts cited by author Peterson in "Plywood in the Sixties," is the work conducted by the Douglas Fir Plywood Association on engineered building components.

The latest example is a new, lightweight component designed for use in larger commercial and light industrial buildings.

Called the delta frame, it is a hollow plywood box beam bent in the form of a central A-frame section that rests on concrete piers and carries cantilevered beams on one or both sides.

In addition to full-scale laboratory tests the component has been proved in a prototype, an open play shelter built for a school in Lakewood, Washington (see illustrations).

The play shelter has the classic delta frame silhouette: a central A-frame section with a rise of 20 feet and a clear span of 40 feet, and two 20-foot flat wing beams cantilevered from legs of the A-frame. Four bents were spaced on 16-foot centers.

A proprietary item, the delta frame is being marketed through Plywood Fabricator Service, and 28 licensed fabricators are prepared to supply any of the standard 608 versions of the basic component.

With these 608 variations, it is possible to produce an entire family of buildings, ranging from supermarkets and industrial plants to churches.

Any conventional roofing system—including stressed skin panels, folded plates, vaults, or standard joists with plywood decking—is possible with the delta frames.

Among advantages of the system, according to DFPA, are reduced on-site labor, quick erection of large buildings, and versatile designs in engineered structures that are economically competitive with less imaginative "low-cost" buildings.

Further information about the new component is available from Douglas Fir Plywood Association, Tacoma 2, Washington, or Plywood Fabricator Service, 3500 East 118th Street, Chicago 17, Illinois.

THE APPLICATION OF:

Hardboards in Construction[1]

ROBERT R. RENDALL
Masonite Corporation, Chicago

Hardboard has become one of the most desirable construction materials today. This report delves into some of the aspects of its versatility, and prophesizes twice the current hardboard market by 1970.

A STRONG RIBBED and embossed surface is easily two-toned for striking effects.

THE HARDBOARD INDUSTRY is no longer a struggling orphan in the building material field. Hardboard today is accepted by the building trade as a desirable and utilitarian commodity.

The physical properties of many building materials do not always lend themselves to the most efficient results in the end usage. This problem is eliminated in a product such as hardboard. Hardboard, because of its nature, can be designed during the manufacturing process with an end-use in view. The density, thickness, surface, and size can be modified. The product can be fabricated in many different forms and shapes relative to the desired end-use.

The present potential demand is about 2 billion feet per year. The domestic sales of the hardboard industry are approximately 2 billion feet per year. This is augmented by approximately 175 million feet per year from foreign imports.

Hardboard has been used for 30 years as an integral part of manufactured products. The furniture, automobile, television cabinet, display manufacturing and other industries in combination consume roughly 50 percent of the domestic hardboard output. The remainder of hardboard production is utilized by the building industry. The hardboard manufactured for building falls into two categories: hardboard for interior application and hardboard for exterior application.

Interior Application

Interior applications consist of door faces, walls, shelving, underlayment, perforated board treatments, cabinet construction, and various types of prefinished hardwood. Plastic-coated hardboard has been in use for some time. Since these panels and planks have a baked on melamine finish, they never require redecorating. For more dent-resistant than natural woods, these prefinished panels resist household acids, alcohol, and other staining agents which would ruin ordinary furniture finishes.

Techniques have been developed recently for reproducing high-fidelity wood grains on hardboard. The wood-grained hardboard lines are extensive and are constantly expanded to include other grains and colors. Various methods have been and are being developed to fasten these new materials to the wall. One of the more unique systems involves the use of metal splines on a 2-foot module in which the edge-grooved, wood-grained hardboard is inserted. The metal spline is slotted in order to accept metal fixtures such as shelf brackets, magazine racks, shoe racks, flower pots, and numerous other fixtures designed for use in this system. This type of wall treatment is unique in that it makes a working wall out of a previously non-functional covering.

Exterior Application

Exterior applications for hardboard constantly increase. A variety of types and thicknesses is on the market now and have become established and accepted products. Hardboard siding products are generally 1/4-inch or 5/16-inch thick and are produced in various sized panels and strips. The

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[1] Presented at the 1959 fall meeting of the Northeast Section of the Forest Products Research Society. Approved for publication in 1960.

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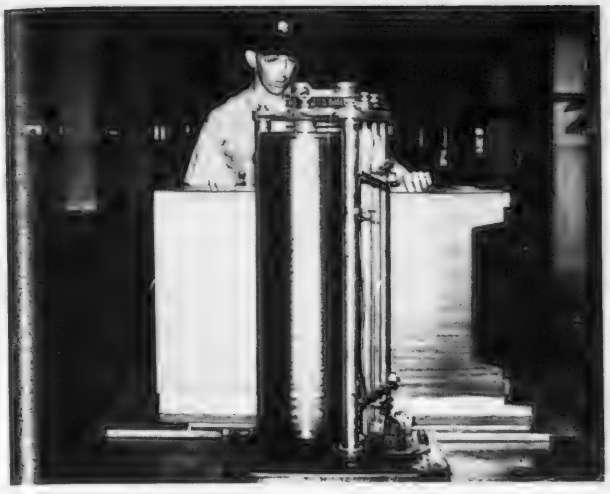

ENTIRE SIDE of a television cabinet, wood and hardboard, is grained at one operation by offset process.

HARDBOARD is used by over 300 furniture makers for cabinet portions, backs, drawer enclosures, and finished panels.

siding products fall into several groups: wide lap sidings, similar to wide bevel or clapboard type sidings; panel type sidings with various grooving, joint, and surface treatments; and board and batten types. A recent development is metal mounting strips which are used in conjunction with horizontal type siding. The metal mounting strip is perforated to ventilate the area behind the siding. This results in a reduction of the moisture content within the wall. This product has the advantages of: 1) less lap loss; 2) less cutting loss since joints do not have to be broken at the studs; 3) reduction in labor costs due to speed of application; and 4) face nailing is eliminated, as the only nailing occurs in the mounting strip which is hidden by the siding.

Hardboard panels are frequently used in soffit construction or any protected horizontal exterior, such as porch ceilings or carport ceilings. Hardboard siding products are often factory primed. This feature enables the user to apply the material to any type of weather. A major advantage of hardboard siding is its superior paint retention. Open grain, knots, and pitch pockets in wood siding, which generally contribute to early paint failure, are becoming more and more prevalent due to the declining supply of good timber. Hardboard siding has a uniform surface with high paint retention qualities.

The prefabricated housing industry, since the end of World War II, has grown from a modest beginning to the point where it is now a substantial factor in the residential construction market. Hardboard exterior coverings lend themselves to this type of construction. Uniformity of materials in size and thickness are factors that are required in this building method. Hardboard panels meet these requirements and, therefore, are utilized extensively in the prefabricating industry.

Research Houses

During the last few years the National Association of Home Builders has launched a program of constructing research houses erected by operating builders in various sections of the country. Three completed research houses are located in Kensington, Md., Knoxville, Tenn., and South Bend, Ind. Many hardboard products, some of which are on the market today, have been incorporated into this program. Sandwich panel exterior walls delivered to the building site in modular sections were used in the Knoxville Research House.

"The exterior wall panels were factory fabricated in two sizes—4′ x 8′ and 2′ x 8′. They were constructed in jigs using a 2″ x 4″ x 4′ top plate and a 1″ x 4″ x 4′ bottom plate. The studs, spaced at 24″, were a 2″ x 4″ for one edge of the center and a 1″ x 4″ for the other edge. Tempered hardboard 5/16″ thick with preformed battens 4″ o.c. was used for a combination exterior siding and sheathing, nailed with 4d galvanized siding nails spaced 4″ o.c. at the four edges and 8″ o.c. at the intermediate stud. The panel was then turned over and blanket insulation was applied. The interior

HORIZONTAL LINE IS accentuated by hardboard ridgeline in this house, designed by Frank Lloyd Wright.

GROOVED and cherry-grained panels of hardboards are installed quickly with metal clips hidden in the joints.

WALLS AND FENCE of this 1959 National Association of Home Builders' Research House were made of ribbed hardboard panels.

skin was ¼" wood grained hardboard which was glued to the framing members and nailed at the top and bottom plate."[2]

The Knoxville N.A.H.B. Research House incorporated hardboard-faced sandwich panels joined with a metal spline for the non-load bearing partitions. Shelf brackets and other fixtures were attached to the splines to add a functional purpose to the walls. This modular component or panel technique for interior partitions further cuts down on labor and material costs.

Floor to ceiling doors with hardboard skins were installed in the Research house. The advantages of this ceiling height door are numerous. Aside from the ease of construction on the job, the opening allows a freer flow of air, thereby increasing the heat-transfer from room to room. The absence of a low header lessens the structural stresses and avoids the cracks that frequently occur at this point. Savings are also realized in material and labor costs.

The trend toward curtain wall construction is apparent in many of our new buildings. Hardboard with porcelain enameled surfaces and hardboard faced panels filled with insulating materials are two examples of how hardboard is, and will be, used in this contemporary type of construction.

[2] N.A.H.B. Research House, Knoxville, Tenn. 1958. A summary report N.A.H.B. File Classification No. 980. (Copyright 1959 N.A.H.B. of the U.S., Washington, D.C.).

Summary

The hardboard industry produced 6 million feet in 1926. Today the industry produces approximately 2 billion feet (⅛-inch basis) per year. This fact alone indicates the overwhelming acceptance of hardboard as a versatile and useful product. In 1954 a Stanford Research Institute study estimated that the total domestic hardboard market would reach 1.6 billion feet by 1960. With the current rate of production now in excess of this figure, it might be reasonable to assume that this figure could be doubled by 1970. This rapid increase in production is due largely to the public acceptance of hardboard as a building material with superior properties. The nature of hardboard, which is adaptable to almost any type of construction or achitectural design, is probably the most significant factor in its acceptance. This, coupled with the many desirable physical properties, makes it one of the most versatile and popular building products in the construction industry today.

PHONE BOOTHS, of striking design, use perforated hardboard backed by fiberglass to absorb sound and tempered hardboard exteriors to resist wear.

CONVENTION HEADQUARTERS

Headquarters for the 15th Annual Meeting of the Forest Products Research Society will be the Kentucky Hotel, Louisville, Ky. Make your reservations now.

A Nondestructive Test for Stiffness

OF STRUCTURAL LUMBER[1]

ROBERT J. HOYLE
Potlatch Forests, Inc., Lewiston, Idaho

RELIABLE METHODS TO ASSIGN working values of elasticity and bending strength are essential to the acceptance of timber as a structural material. Methods generally used to assign safe working stresses exist in the stress grading procedures described in the *Wood Handbook*. The widespread use of wood as a structural engineering material must be credited to this carefully designed system of grading and the skill with which it is applied by certified association graders.

Stress grading by visual methods, although effective and reliable, has one important shortcoming. It is not a precise method. Since it cannot be precise, it has been made conservative. Such stress graded lumber is assigned working or design stresses that border on the low end of the range of strength properties for the material within each grade. The assigned values of elasticity, however, approximate the average for each species.

Table 1 illustrates the degree that current stress grading methods underestimate the flexural strength of structural lumber. These data are from a series of tests on samples of three grades and sizes of four commercially important species. The material was gathered and tested by the Oregon Forest Research Center, the Industrial Research Division of Washington State College, and Potlatch Forests, Inc. This research was not connected with the mill sampling studies which are being conducted by these two organizations for the Western Pine Association.

The average allowable bending stresses, as shown in Table 1, are more than twice those allowed by current grading practices. Statistical treatment of these results gave estimates that 95 percent of this material exceeds the stress ratings now permitted, while 75 percent of the material would be almost twice as strong.

A huge portion of stress graded lumber is being rated well below its useful safe load-bearing capacity. Further sampling of graded lumber might yield slightly different results, but it is evident that an inspection system which would nondestructively test each board would permit utilization of a large part of the structural lumber now manufactured at much higher stress values.

The inefficiency of visual grading methods results in much stress-graded lumber being rated below its load-bearing capacity. When the industry is able to grade by precise nondestructive tests, high costs of "overconservative" stress grading will be reduced, and lumber will be marketed according to actual capacity. Here's one step toward that goal—a fast, reliable, automatic test for measuring stiffness. Equally important, the cost of equipment is within reach of most mills and structural laminators.

The inefficiency of visual grading methods has been long recognized. The engineers who developed the visual system of stress grading were the first to realize this problem. It is the price we pay for want of a more precise method of inspection and grading. When the lumber industry is able to apply a precision nondestructive test to every piece of lumber that emerges from the planer, it will be possible to classify and market each piece for use at loads closer to the potential capacity of the material.

Meeting the Opportunity

There are several ways that this testing operation might be achieved. Some methods which are under development at Potlatch Forests, Inc., are described. These methods may emerge from the laboratory and become production realities very soon.

The introduction and acceptance of nondestructive stress grading by the industry and the consumer are the next important steps to be taken. The engineering problems are well on the way to solution. Further development work, engineering, and research are necessary, but results to date indicate one nondestructive test principle which will work on the production line. Other approaches may prove more precise and more efficient, but the methods described offer high speed mechanical testing machines which will be suitable for the lumber industry. Equally important is the possibility that equipment based on these methods can be manufactured at costs within the reach of most mills and structural laminators.

The principle of nondestructive testing under study at Potlatch Forests is a simple mechanical bending test, rapidly applied to individual pieces of lumber. By measurement of the force required to impart a measured deflection to a joist, plank, or stud, the machine can indicate the stiffness of the piece. This principle is used in a device which accurately measures stiffness.

A pilot model of one such machine, in experimental use for about a year, is shown in Figure 1. In one test run, it measured the stiffness of lumber 1

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This study was proposed by Dr. H. B. McKean; H. Keller, G. Scheelke, W. G. Edward, and L. K. Floan made important contributions. B. Coulter and C. Glover, Jr., and staff members of the State and Federal forest products research organizations assisted.

[1] A contributed paper approved for publication April, 1960.

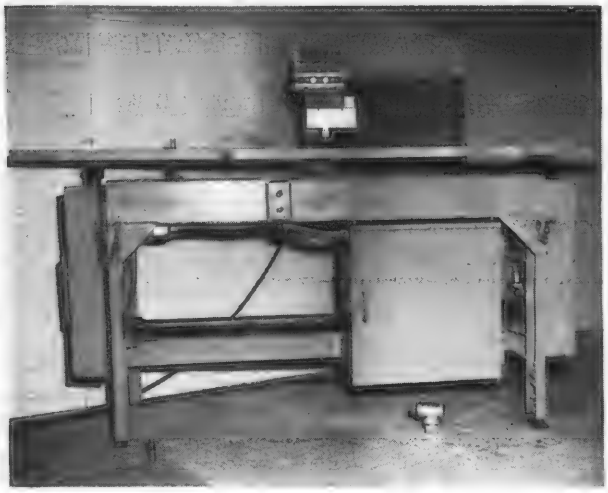

Fig. 1.—Pilot model of stiffness tester for rapid testing of individual boards.

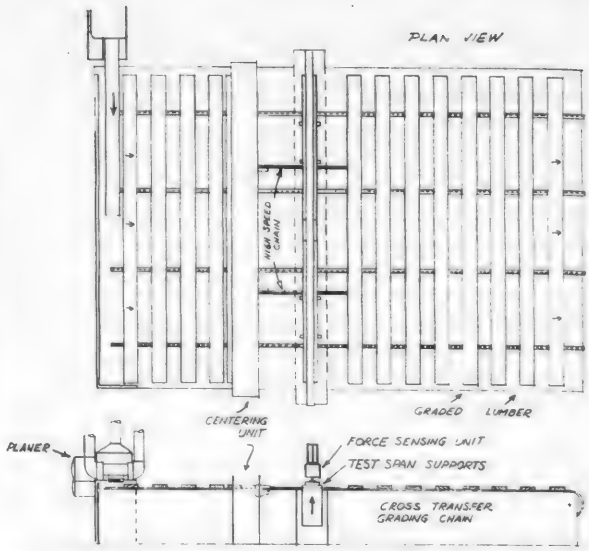

Fig. 2.—Layout for a stiffness tester on a production line (side view).

million times at a testing rate of 30 boards per minute. During this time a number of improvements have been made, but the basic design has changed little and all the original components have functioned without wearing out. This represents the type of reliability needed in such a machine. It is equal to over three months of continuous one-shift production, handling about 12 million board feet of material.

The operating principle is comprehensible, and the equipment should be easy to introduce into the average lumber mill. The components are fairly standard items of equipment, slightly modified in some cases. The force is measured by a modified Dillon force dynamometer. The relays, pneumatic cylinders, solenoid values, and switches are ordinary types that are commercially available.

A special system to insure the application of a predetermined deflection to each board is an essential feature. This compensates automatically for bow, twist, and warp in the lumber. The pilot model indicates stiffness by lights and counters, and an automatic stamper actuated by the same circuit which controls the lights will mark and identify the boards for stiffness.

The production model of this machine will be more versatile. It will be necessary to provide for handling boards of different lengths, widths, and possibly of different thicknesses. These features may be incorporated in a single machine or in several more simple machines located on a dry chain, each one to handle a specific width or series of lengths of board.

There is also a possibility of incorporating more refined electronic equipment into the design to simplify it, yet increase its versatility. This is under development, and there is little question that it is a suitable application for the modern electronic measuring, read-out, and memory devices now available to us. One of these machine arrangements is diagrammed in Figure 2. The boards are tested while moving on a cross transfer chain.

An alternative method to measure the stiffness by the bending test principle as the boards are moving at high speed from a planer has also been successfully tested at Potlatch Forests. This is called the "Endo" method. The lumber travels through two sets of rolls. At the mid-point of each span, it is deflected by a roll mounted on a load cell. The board is deflected in one direction when it passes over the first set of rolls and in the opposite direction when it passes over the second set of rolls. The applied force is integrated electronically to obtain a true average for the piece. The resultant average stiffness determination then selects the proper marking stamp for the identification of the properties of the piece.

In comparison to the other type of machine described, the "Endo" method appears to have a number of advantages, although they are not fully evaluated. The "Endo" machine might have a higher first cost than the cross-transfer machine but it may well be better suited cost-wise and performance-wise than the type which employs the force dynamometer for testing. There is also a distinct possibility that the cross-transfer machine equipped with electronic sensing equipment will be more versatile and lower in cost than this type using the dynamometer.

Probably each of these styles of stiffness tester will have its place, depending upon the size of mill and the degree of automatic sensing which is required. The cross-transfer machine with its lower first cost should be particularly well suited to the sorting and grading of laminating material used in the manufacture of glued laminated structural members.

At present it is not possible to present exact costs. However, our purpose is to produce equipment within the reach of the vast majority of mills that produce structural lumber. Unless this system can receive widespread acceptance, its value is reduced. We continue this development because we believe that methods of this type will find widespread general use.

From Stiffness Testing to Grading

For a new grading system to be useful, it must be widely acceptable. To be acceptable, it must be economically feasible and attractive. There must be no further complication of grades but, instead, a simplification of grades. This is what we propose.

The testing machines described are stiffness testers. They measure the effective stiffness of the board, the product of modulus of elasticity (E) and moment of inertia (I). The machines are calibrated to measure the EI product for the various standard lumber sizes and to assign a value of E to the tested pieces which will permit the user to design on the basis of standard lumber sizes. Architects and engineers do design on the basis of standard lumber sizes. A safety factor is provided to cover the possibility of obtaining scant lumber. With the new grading method, this practice will not

Table 1.—PROPERTIES OF TWO COMMERCIALLY IMPORTANT STRUCTURAL SPECIES

	Douglas-fir		Larch	
	Select Structural	Construction	Select Structural	Construction
Flexural Stress				
Average adjusted* stress in bending	4740	3130	4250	3520
Working stress of 75% of sample	3550	2400	3500	2780
Working stress of 95% of sample	2560	1350	2430	1740
Stress rating now used	1900	1500	1900	1500
Elasticity†				
Average Modulus of Elasticity	1,970,000	1,730,000	1,825,000	1,725,000
M. O. E. of 75% of sample	1,735,000	1,520,000	1,617,000	1,520,000
M. O. E. of 95% of sample	1,400,000	1,220,000	1,345,000	1,235,000
Modulus of Elasticity now used	1,760,000	1,760,000	1,760,000	1,760,000

*Bending values have been adjusted from test values by factors of 2/3 for duration of load, 3/5 for accidental overload and 1.1 for "normal loading." All values are for seasoned lumber at 12% Moisture Content.

†Elasticity values corrected for /d ratio of 14 for standard conditions of test.

b· necessary as far as scant lumber si·e is concerned.

If the manufacturer finishes his lumber undersize the grading method will penalize the material with a low E value. If he runs it full, he will receive a higher E value. Similarly, if the manufacturer does a good job of lumber drying he will obtain a better stiffness grade than if he machines and grades the lumber without adequate seasoning. The grading method has built-in incentives for good size and drying control in manufacturing.

A number of questions come to mind when a person first begins to seriously examine this proposed nondestructive grading method. There is a tendency to visualize the addition of elements to the machine to measure auxiliary quantities which might influence stiffness and feed these measurements into a complex computing mechanism to apply various corrections to the result. This might improve precision but would also produce a machine of a highly complex design, too loaded with gadgets. If it were necessary to automatically sense lumber width, thickness, moisture content, temperature, the cost and practicability of the machine begin to shade the interest of the average lumberman. Fortunately measurement of all these features does not appear necessary, although some small forfeit of precision is involved.

Moisture Content

Consider moisture content, for example. Nearly everyone recognizes the fact that modulus of elasticity increases as wood dries, and that wood shrinks as it dries. What will happen to a piece of lumber graded at 19 percent moisture content and used at 12 percent? The loss in dimensions of cross section reduces the value of I. The loss in moisture causes an increase in E. On the basis of shrinkage and elasticity change relationships given in the *Wood Handbook,* the net result of this process is to produce higher EI product at 12 percent than at 19 percent. A series of tests on pieces machined to size when green and tested when green and when air dried are shown in Table 2. The differences in EI products green and air dry were consistently neither positive nor negative, and they were not statistically significant. Therefore, it may be that moisture content will not be a significant source of error. Some further study is desirable on this matter.

Size Detection

The automatic stiffness tester could be designed to sense the width and thickness of lumber and feed this information into a computing system. We do not believe this is necessary, since the principle of measuring EI product and assigning E based on standard lumber size is invoked. This lends itself well to utilization of stiffness classifications in design with timber.

It will be necessary to provide adjustable calibration ranges which can be easily selected to suit the size of lumber processed at any time. An automatic sensing element to distinguish between the various standard lumber sizes is desirable to preclude human forgetfulness in making the selection. But precision in size sensing, beyond the standard lumber widths, seems unnecessary.

The cross-transfer chain type machine will need to sense lumber length and select the proper support anvils and force system multiplier. This will be a part of the centering unit (see Figure 2). Overhanging ends present no problem as far as any effect on the accuracy of testing is concerned.

Temperature Effects

The modulus of elasticity of wood is influenced by temperature. The mean daily temperature of solid piled lumber may fluctuate considerably from winter to summer in some climates. Lumber planed shortly after leaving the kilns may conceivably be warm even in winter. Lumber temperature, therefore, should be considered at time of test.

Wood undergoes a reduction in stiffness as it becomes heated. Some tests in our laboratory showed that the modulus of elasticity of Douglas-fir changes 2,300 psi per degree change

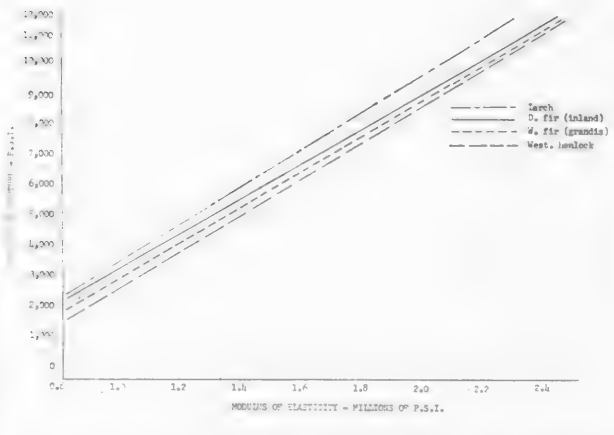

Fig. 3.—Schematic relationship between stiffness and strength.

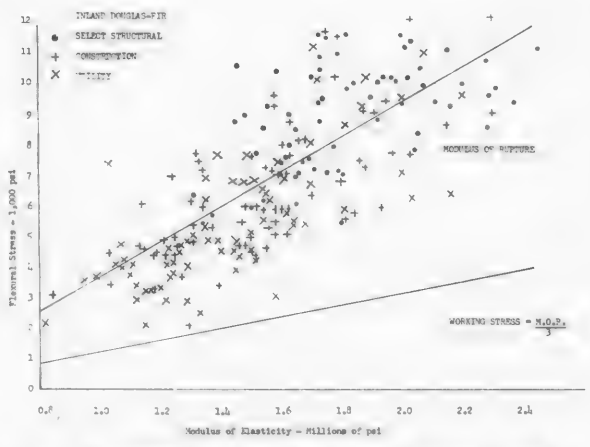

Fig. 4.—Schematic relationship between allowable working stress and stiffness.

in lumber temperature (about 0.13 percent of E per degree Fahrenheit). The value for white fir was about one-half of that for Douglas-fir.

Since the effect of temperature is so small, a seasonal adjustment in machine calibration can be made to insure safety. The testing of hot lumber from the kilns would do nothing but penalize the manufacturer, by the effect both of temperature and moisture content on the grade which the automatic stiffness tester will measure.

Speed of Testing

The effect of testing speed on modulous of rupture is widely recognized by wood researchers. Since both nondestructive stiffness testers operate rapidly, interest is natural in the effect of speed on stiffness. None of the investigations made at the U.S. Forest Products Laboratory have shown an effect of testing speed on stiffness. Creep is evidently too slow to significantly affect the stiffness test. No studies of this relationship in the short load duration ranges which occur in the proposed nondestructive testing method have been found. The machines can be calibrated to compensate for any speed effect that may be discovered. Evidence of such an effect has, however, not been observed.

Edge Versus Flat Testing

The automatic stiffness testers described measure the performance of the specimens when laid flat, as planks. Structural lumber is often used in this way, particularly in laminated beams and decking. Since joists are an important use for structural lumber, will testing boards flat indicate the performance of the boards when used on edge?

The impellent reason to test the lumber flat is the opportunity to obtain a sizeable deflection without creating large fiber stresses. A significant deflection is needed to obtain precision in measurement and a moderate fiber stress is desired to avoid harming the lumber during the test. Testing on edge is not impossible but requires more sensitive deflection measuring instruments.

Some studies of knot distributions in boards are now being conducted. It appears that the ratio of moment of inertia of knots to gross moment of inertia of the sections do not differ greatly with respect to the two principle directions of the neutral axis of a section. Also, a series of tests of white fir dimension has shown that the moduli of elasticity measured on edge versus flat are approximately equal. The question is not completely resolved, but the problem can be provided for in the calibration of the testing equipment as soon as the relationship is clearly defined.

Table 2.—INFLUENCE OF DRYING ON EFFECTIVE STIFFNESS OF 2 X 4 DIMENSION

	White Fir Flat Grain	White Fir Edge Grain	Douglas-fir Flat Grain	Douglas-fir Edge Grain
Green				
Used Flat:				
E* X I†	1,700,000	1,807,000	1,932,000	1,611,000
E	1,310,000	1,390,000	1,485,000	1,240,000
Used on Edge:				
E X I	6,817,000	6,630,000	7,788,000	6,858,000
E	1,057,000	1,030,000	1,208,000	1,065,000
Dry (12%)				
Used Flat:				
E X I	1,847,000	1,819,000	2,065,000	1,728,000
E‡	1,420,000	1,400,000	1,585,000	1,328,000
Used on Edge:				
E X I	6,619,000	6,355,000	6,912,000	7,653,000
E	1,028,000	987,000	1,072,000	1,186,000

*E = Modulus of Elasticity.
†I = Moment of Inertia.
‡This is the effective modulus of elasticity to use in a structure designed for standard lumber sizes.

Prediction of a Working Stress in Bending

The testing devices described in this report are called "stiffness testers". Stress graded lumber carries a working stress in flexure as well as a modulus of elasticity, shear strength, and compressive strength parallel to the grain. Although stiffness is often the limiting design property for joists and beams and usually the limiting factor for plank and decking applications, bending strength is a necessary design characteristic.

This stiffness tester program began as a result of concern over the differences in stiffness assigned to coast and inland varieties of Douglas-fir. The original laboratory tester made possible the rapid examination of large quantities of structural lumber for stiffness.

Studies of the correlation between strength and stiffness of four commercially important species of western timber have been conducted. The Oregon Forest Research Center, Washington State University, and Professors John Howe and Arland Hofstrand of the University of Idaho have all contributed to the collection, testing and analysis of this relationship between modulus of elasticity and modulus of rupture. The important results and proposals for working stresses based on stiffness are presented in a paper (H. B. McKean, Symposium, Fiftieth Anniversary of the State University College of Forestry, Syracuse University, April 13, 1961).

Figure 3 is a graph of the relationship between stiffness and strength for four species. The similarity of the slopes of these curves is striking. The significant correlation coefficients were all between 0.7 and 0.8. The regression coefficients tested against the hypothesis that they might be zero were highly significant of a positive slope.

In Figure 4, a method to predict a working stress of one-third the modulus of rupture from the regression curve is indicated. This is, we feel, a conservative approach being that it has been used for many years. It is based upon the ¾ for variability, ⅔ for duration of load, 3/5 for accidental overload, and 1 1/10 for "normal loading." This paper offers specific proposal on working stresses. We merely present Figure 4 to show that a conservative treatment yields working stresses that are enormously improved over those customary values for structural lumber.

Summary and Forecast

The development work at Potlatch arose from the need to resolve the differences between assigned design properties and the higher load bearing capabilities of many individual pieces of structural lumber in a number of important commercial species. The penalties imposed on lumber by some codes and regulatory agencies are severe. An improved inspection and grading method seems necessary.

We have reached a point where the possibility of achieving a method of rapid measurement of one mechanical property correlated with other properties needed for a grading system is within grasp. Our next step is to determine the type of grades that can be established. Attention should be paid to the problem of introducing an improved grading system without upsetting existing methods or confusing the grade picture for the consumer. The validity of stiffness and strength relationships in lumber with normal defects of the grade should be explored, explained, and settled. The job certainly is not completed, but we feel it is well begun with clear possibilities and opportunities for the lumber industry and the consumer public.

PERFORMANCE OF SOME

Blister-Resistant Paints[1]

JOHN N. CROSBY

Weyerhaeuser Company, Longview, Washington

The history of the exterior paint-blistering problem is analyzed. Several solutions are presented with emphasis on oil-base blister-resistant paints. Facets such as the overall performance, the performance on Douglas-fir and hemlock, and the limitations of the paint were explored.

WOOD EXTERIOR SIDING in various forms has been used for hundreds of years, but the problem of serious paint blistering on siding is comparatively recent. It was not a problem in early home construction that used bevel or flat clapboard siding even though examination today reveals a multiplicity of paint coats on such siding. Such painting practices are considered hazardous today.

The paint blistering problem on exterior siding appeared early in the century. During the last 10 to 15 years, it has grown, and is now of serious concern to siding manufacturers, paint manufacturers and consumers. The reaction of the consumer to the problem has been violent. He has had little desire to analyze the problem; he can see blisters, the blisters are on the siding, so he generally assumes that the fault lies in the siding. This situation has made the wood siding market vulnerable to competition from other materials. Manufacturers have seen the problem develop to the extent that paint blistering has become a significant factor in wood siding sales.

During the last 10-year period, a great deal has been done to analyze the problem in the search for a solution.

Review of Findings

Many of us have been confronted with exterior paint problems. These probably have included paint blistering, so we can identify the physical appearance of this often perplexing situation. In our field studies, we have observed paint failures caused by blistering over part or all of one wall or, in extreme cases, over most of the exterior surface.

Numerous factors directly connected with dwelling design, construction practice, and use of the dwelling as well as methods and types of paint applied have contributed to the problem. The increased frequency of paint blistering can be attributed to:

1. Tighter wood construction that results from improved quality of lumber manufacture and building skill, wide use of asphalt shingles and built-up roof coverings.
2. Change from 25/32-inch wood sheathing to ½-inch competitive products that do not absorb and hold water as well, and, therefore, do not regulate flow through the siding to eliminate peak loads.
3. Reduced size of homes, the cubic volume has decreased during the past years, ceiling height has been reduced, roof pitch has been lowered combined with a tendency for less overhang. More single story houses and fewer basements are built.
4. Increased use of air conditioning and more efficient heating systems have resulted in the combination of warmer interior walls and controlled higher humidities.
5. Additional increased humidity within the home that results from the modern automatic conveniences, two or more bathrooms with showers and their extensive use in daily life.
6. Increased use of insulation without properly and adequately applied vapor barriers.
7. Increased use of window walls and sliding glass doors which are perfect vapor barriers.

The common denominator of these factors relative to blistering and paint maintenance is moisture. This moisture, is created within the structure and will diffuse as vapor through the permeable exterior surfaces. The rate and extent of diffusion and the point of moisture build-up at any time depends upon the weather conditions, but eventually the moisture will pass out of the structure. That moisture which moves through the walls can cause blistering.

Moisture may also arise from and build up in the wall from exterior sources. This usually results from melting snow and ice, and rain which enters the siding laps and end joints by capillarity and diffusion causing wetness in back of the siding. This situation often creates a moisture blistering problem in the milder climates where cold weather condensation of moisture from within the home normally is not a factor.

A paint film blisters on siding when the bond between the film or coating and the substrate is weakened by an excessive moisture build-up. This results in water swelling the paint film, actual pressure (vapor or liquid) acting against the paint membrane, or a physical loss of adhesion caused by moisture.

These factors have been generally recognized by the lumber and paint industries, and each have actively sought solutions. Although these efforts have often been along divergent lines, progress in the overall solution of paint blistering has been encouraging.

Many lumber manufacturers now offer water-repellent-treated siding products. This treatment although not a complete panacea, does provide beneficial effects both to the wood siding product and the paint performance. Both laboratory and field trials by industry and independent laboratories have demonstrated the ability of the treatment to markedly reduce the pick-up of liquid water from sources outside the wall and thereby protect the paint film. There is evidence also that both conventional and blister-resistant oil-base paints are more durable when applied over water-repellent-treated siding.

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[1] Presented at the meeting of the Northwest Section of the Forest Products Research Society, Bellingham, Wash., 1960. Approved for publication, February, 1961.

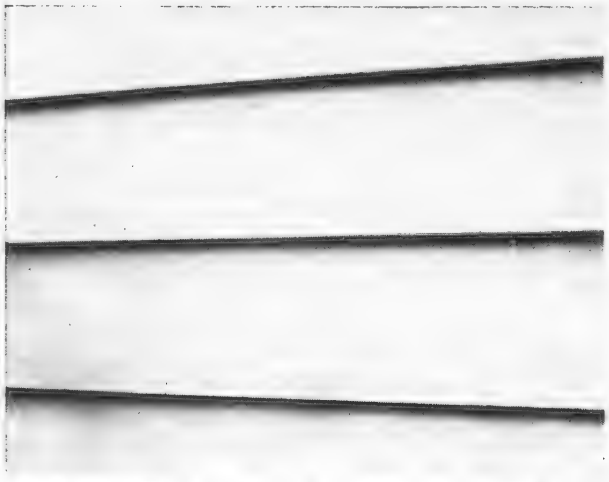

Fig. 1.—Condition of siding on Longview Test House 7 years after treated siding was applied. There was a complete lack of blistering over the treated siding.

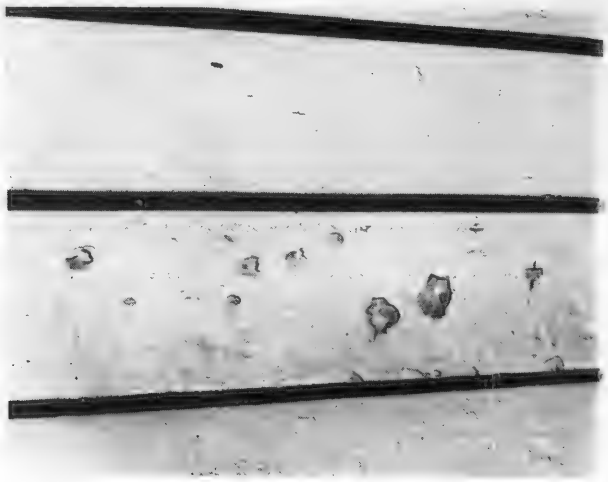

Fig. 2.—Condition of untreated siding on Longview Test House, showing evidence of current as well as past blistering.

Methods and Materials

In this regard, a program initiated by our company some eight years ago in cooperation with the U. S. Forest Products Laboratory at Madison, Wisconsin, has offered definite evidence as to its value. A house located in Longview, Washington, with a serious paint blistering problem since occupancy by the original owners was partially re-sided with water-repellent-treated cedar and hemlock bevel siding in 1952. It was then repainted with a conventional oil base paint as used originally. Although the remainder of the house has shown discouraging and frequent blistering, and the re-sided (treated) portion has remained entirely blister-free during the past seven years (Figures 1 and 2).

In another approach to a solution of paint problems, the lumber industry initiated and investigated the performance of blister resistant oil-base paints. I emphasized oil-base because the paint industry presently manufactures and offers exterior emulsion or latex paints which are represented also as blister-resistant coatings.

The oil-base blister-resistant paints may be defined as exterior coatings formulated to provide non-water sensitive films that have maximum adhesion to wood.

Such paints vary considerably in composition but generally contain an alkyd or modified alkyd resin vehicle. Vegetable drying oils, copolymer solutions, and dicyclopentadiene resin vehicles are also used. The vehicle generally comprises more than 50 percent, by weight, of the total paint, higher than in conventional paints. The pigment is always titanium dioxide but usually extending pigments such as silicates and carbonates are included in the formulation. Zinc compounds are rarely, if ever, used. Since the pigment is usually less than 50 per cent by weight, of the paint, the specific gravity of the blister resistant paint is lower (less than 1.5) than for conventional paints which range between 1.5 to 1.7. These paints, as a rule contain a mildewcide. (For purpose of comparison, we use the term "conventional paint" to designate those oilbase paints which contain lead, zinc, and titanium or combinations of these pigments.)

Some of the original work on the evaluation of the blister resistance of paints was done under the auspices of the Special Paint Committee of The National Lumber Manufacturers Association by the TECO Laboratory in 1955 and 1956 (1, 2).[2] This work was further refined by a program sponsored by the Western Red Cedar Lumber Association (3). It was established that a number of paint companies with large combined distribution do produce exterior paint products which, when compared to conventional house paints, are blister resistant.

In the latter program, tests were made on paint performance at the TECO Laboratory and reported in 1958 (3). Some 19 blister-resistant oil-base paints and two conventional paints were included in this study. They were applied and dried as recommended (the blister-resistant paints were self primed; the recommended primer was used under the conventional topcoat paints) to cedar bevel siding. Blister and Weatherometer tests were conducted. The Weatherometer tests, which were run for 864 hours, were not, in our opinion, conclusive. However, it was reported that paint durability was good.

The blister tests were run for 14 days with a 16 hour cold (from 20° to 25°F.) and 8-hour warm (room temperature) exposure to the painted face and 100 percent relative humidity in the test box. Fifteen of the 19 paints did not blister. Of the other four, less than 8 percent, of the total surface area blistered. The conventional control paints showed up to 65 percent of the area blistered under the same exposure.

The results of this work were most encouraging because they indicate another solution to the paint blistering problem. In the study of the information, we felt that additional investigation was needed to supplement this data for use use. We wanted to know:

1. The overall performance, including application, appearance, durability, and repaint characteristics.
2. The performance of these paints on species other than western red cedar, specifically on Douglas-fir and hemlock.
3. The limitations, if any, in the use of oil-base blister-resistant paints.

To determine the performance The Lumber and Plywood Development Department, Weyerhaeuser Co., conducted laboratory and outdoor exposure tests on selected blister-resistant and conventional paints. Field contacts were also made in the course of this work.

The tests of blister resistance and exterior durability were made on western red cedar, Douglas-fir, and hemlock, using four blister resistant and two conventional paints. Matched samples of ½ by 8-inch bevel siding were used in each case and half of these samples were water-repellent-treated prior to painting. In the exterior exposure tests, both flat and vertical grain siding were used. Each paint was applied as a two-coat system at the rate of 450 and 500 square feet per gallon

[2] Numbers in parentheses refer to Literature Cited at the end of this report.

Fig. 3.—Blister-resistant paint after 14 cycles on blister box.

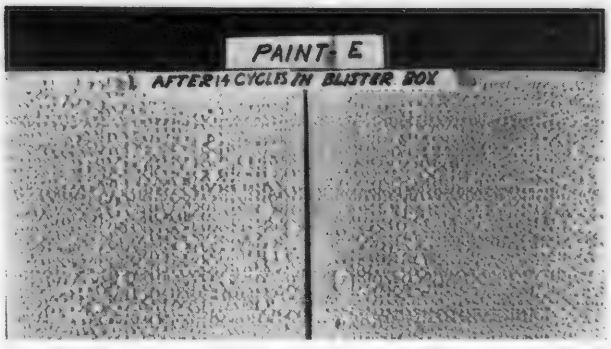

Fig. 4.—Conventional paint after 14 cycles on blister box.

f r the priming and finishing coats, re- s ectively. The prime coat was dried f r 72 hours, and the final coat for 14 d ys under interior conditions. Infor- n ation on the wet film characteristics w as recorded during the painting o erations.

The blister test used by Weyerhaeu- s r involved a plywood box measuring a out 34-inches square and 14-inches h gh with a thermostatically controlled w ater bath, an interior circulating fan, a d 12-inch by 6-inch equally spaced o enings with sample hold downs in t e top. The test samples were 7-inch b 7-inch. The ends and edges of each s mple were sealed with a high melt- i g point wax after painting and be- f re exposure. The blister test was conducted for 14 days with a 16-hour cold (40°F.) and 8-hour warm (room temperature) cycle. Daily observation was made of appearance, percentage of blistered area, blister size (based on ASTM 714–45), and the increase in moisture content (Figures 3 and 4).

Exterior exposure panels, 3-foot wide by 8-foot long were made up using bevel siding as normally installed with sheathing on a 2 by 4 frame. The backs of the panels were covered with 90-pound roofing. These were mounted outside in our mill area at 45° F. with the horizontal, and facing south. They have now been exposed for one year.

Appraisal

As a result of all this work, including our own tests, we feel the following comments represent a fair appraisal of the oil-base blister-resistant paint performance.

Application: Rate of application, coverage, and drying time of these paints are normal and comparable to conventional paints. Like conventional paints, two coats are usually applied to new wood surfaces; however, this does not provide an adequate dry film thickness for maximum paint life. We would like to see three coats recommended and used.

Appearance: The dry, unweathered paint film has a medium to low gloss. Although usually lower in gloss than the conventional paints that contain zinc, they are not considered flat. Hiding power or opacity is good. The weathered film shows good color and cleanliness.

Performance: The blister resistance of these paints was confirmed by our tests. No blisters occurred over the full exposure period on any of the species despite the fact that the moisture content of the substrate increased far above the fiber saturation point. The conventional paints blistered severely.

In running these tests we found less than 5 percent difference in moisture content of the substrates with conventional paint versus blister-resistant paint. Therefore, we concluded that these particular paints do not owe their blister resistance to moisture impermeability.

Our tests have not been sufficiently exposed to draw conclusions regarding paint integrity and durability. However, discussions in the field and the results of other tests indicate blister-resistant paints have satisfactory durability and even wear, providing good surfaces for repainting.

Mildew Resistance: All paint films are subject to attack by mildew. Conventional paints derive resistance to such attack by virtue of the types of pigments used. Blister resistant paints may be deficient in this property under extreme humidity conditions. When mildew is known to be a problem, additional mildewcide should be added to the paint.

Repaint Properties: Experience indicates that application of blister resistant paints over similar weathered coatings is satisfactory and will continue to give good performance. However, these paints cannot be expected to provide blister resistance where blistering has occurred previously unless the old coating is removed.

As a result of this work, we feel that the overall performance of these paints is satisfactory. We do not anticipate specific limitations to the use of quality blister-resistant paints if correctly applied.

Summary

The history of the exterior paint blistering problem on wood siding is reviewed from the standpoint of time and the major causes. These are identified as associated with changes in home building materials, and design and construction of the home and its use. These changes are related to moisture, the primary cause of paint blistering.

Recognition of the causes of the paint blistering problem on siding by the lumber industry have led to the introduction and use of water-repellent treatment. It also led to the recognition of oil-base blister-resistant paints.

The blister resistance of these paints was demonstrated by tests sponsored by the NLMA and WRCLA. A further investigation was made by Weyerhaeuser which established that the blister-resistant properties applied to Douglas-fir and hemlock as well as cedar siding. It is concluded that these paints are satisfactory and their use should be more widley recommended as exterior coatings for wood siding.

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CONTROL OF BROWN STAIN

In Eastern White Pine[1]

ROBERT E. STUTZ, PETER KOCH, and MILLARD L. OLDHAM

Degrade caused by brown stain and blue stain in eastern white pine was virtually eliminated by the use of sap stain chemicals and sodium azide. Combinations of buffered sodium azide with both sodium pentachlorophenate plus borax and buffered ethyl mercury phosphate were effective.

THE BROWN STAIN FOUND IN eastern white pine *(Pinus strobus L.)* is essentially identical to that found in western white pine *(Pinus monticola)* in degree, rate of stain development, and general stain appearance. Stain development is dependent on the presence of oxygen, moisture, and is greatly accelerated by high summer temperatures and humidities. Unlike stain in sugar pine,[2] the appearance of this stain is not as dependent on the secondary oxidation step or the dry-kiln step in that it can be induced under air seasoning conditions. Prevalence of the stain is generally associated with an induction period during the hottest and most humid part of the summer, followed by normal kiln drying.

Since brown stain development in eastern white pine is most severe during July and August, the field test was installed at the Champlin Company in Rochester, New Hampshire during this season. Grading of the lumber was done under the supervision of Dr. Koch. Approximately 20 percent of the lumber taken from the sawmill green sorting chain was rejected because of the presence of log-borne blue stain. In spite of this selection, an added burden was placed on the blue stain control agents because the leading hyphae of the fungi are an undetermined distance ahead of pigment development. Therefore, the assumption follows that some blue stain would escape observation and appear in the anti-blue stain treated solid piled portion of the samples.

Methods and Materials

Six groups of 50 eastern white pine boards ranging in size from 1-inch-by-6-inch-by-8-foot to 1-inch-by-10-inch-by-8-foot, which were examined before treating to be certain none contained any blue or brown stain, were treated per 100 gallons of solution with 4 pounds of 12.50 percent sodium azide and a borate-carbonate buffer (Bazide); 10 pounds of 35.00 percent sodium pentachlorophenate in a borax buffer (Permatox 10–S); 10 pounds of 12.50 percent sodium azide and a borate-carbonate buffer plus 4 pounds of 35.00 percent sodium pentachlorophenate in a borax buffer (Permatox 10–S plus Bazide); 2 pounds of 6.25 percent ethyl mercury phosphate in a carbonate buffer (Timsan); 2 pounds of 6.25 percent ethyl mercury phosphate in a carbonate buffer plus 2 pounds of 12.50 percent solium azide and a borate-carbonate buffer (Timsan plus Bazide); and a control. The boards in this series were placed in the dry kiln immediately after treatment.

Twelve groups of approximately 50 eastern white pine boards ranging in size from 1-inch-by-6-inch-by-8-foot to 1-inch-by-10-inch-by-8-foot were solid piled one week before drying in the kiln. This series was treated per 100 gallons of solution with 2 pounds of Bazide; 4 pounds of Bazide; 8 pounds of Bazide; 10 pounds of Bazide; 10 pounds of Permatox 10–S; 10 pounds of Permatox 10–S plus 2 pounds of Bazide; 10 pounds of Permatox 10–S plus 4 pounds of Bazide; 10 pounds of Permatox 10–S plus 8 pounds of Bazide; 2 pounds of Timsan; 2 pounds of Timsan plus 1 pound of Bazide; 2 pounds of Timsan plus 2 pounds of Bazide; 2 pounds Timsan plus 4 pounds Bazide; and a control.

Both series of boards were completely sprinkled on both sides and ends to insure complete coverage. A garden sprinkling can was used, since a dip tank was not available. Experience has shown that results obtained by this procedure are identical to those from the usual dipping operation.

Each board was graded according to the mill's modification of the white pines grading standards for the paneling grades of stock produced. The dollar degrade values were calculated on the basis of accumulated experience of

Table 1.—EASTERN WHITE PINE BROWN STAIN FIELD TEST NUMBER OF BOARDS DEGRADED*

	Untreated	4 lb. Bazide	P-10-S	P-10-S Plus 4 lb. Bazide	Timsan	Timsan Plus 2 lb. Bazide
Number of boards in sample	38	50	49	47	45	47
Brown stain present but no degrade	0	3	2	2	4	2
Blue stain present but no degrade	0	0	0	0	0	0
Downgraded 1 grade with brown stain	18	1	0	0	0	0
Downgraded 1 grade with blue stain	0	1	0	0	0	0
Downgraded 2 grades with brown stain	7	0	0	0	0	0
Downgraded 2 grades with blue stain	2	0	0	0	0	0
Boards containing brown stain	25	4	2	2	4	2
Number of unstained boards	11	45	47	45	41	45

*Stock treated and placed directly in the dry kiln.

The Authors: R. E. Stutz has a Ph.D. in biochemistry from the University of Wisconsin; he is research director of the Chapman Chemical Co., Memphis, Tenn. P. Koch has a Ph.D. in forest products from the University of Washington, and is vice president of the Champlin Company, Rochester, N. H. M. L. Oldham has an M.A. from Memphis State University and is research chemist of the Chapman Chemical Co.

[1] A contributed paper approved for publication February 27, 1961.

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Table 2.—EASTERN WHITE PINE BROWN STAIN FIELD TEST*

	Untreated	2 lb. Bazide	4 lb. Bazide	8 lb. Bazide	P-10-S	P-10-S plus 2 lb. Bazide	P-10-S plus 4 lb. Bazide	P-10-S plus 8 lb. Bazide	Timsan	Timsan plus 1 lb. Bazide	Timsan plus 2 lb. Bazide	Timsan plus 4 lb. Bazide
No. of Boards in sample	50	49	49	49	49	50	50	50	49	50	50	50
No. of boards with brown stain but no degrade	1	4	1	1	7	1	2	1	14	7	1	2
% of boards with brown stain but no degrade	2	8.2	2.0	2.0	14.3	2	4	2	28.6	14	2	4
No. of boards with blue stain but no degrade	38	0	0	0	0	0	0	0	0	2	4	0
% of boards with blue stain but no degrade	76	0	0	0	0	0	0	0	0	4	8	0
No. of boards downgraded 1 grade with brown stain	14	6	2	0	27	0	2	1	10	5	3	0
% of boards downgraded 1 grade with brown stain	28	12.2	4.1	0	55	0	4	2	20.4	10	6	0
No. of boards downgraded 1 grade with blue stain	0	0	2	0	1	0	0	0	1	0	0	0
% of boards downgraded 1 grade with blue stain	0	0	4.1	0	2.0	0	0	0	2.0	0	0	0
No. of boards downgraded 2 grades with brown stain	35	0	0	0	12	0	0	0	0	0	0	0
% of boards down graded 2 grades with brown stain	70	0	0	0	24.5	0	0	0	0	0	0	0
No. of boards downgraded 2 grades with blue stain	0	0	0	0	0	0	0	0	0	0	0	0
% of boards downgraded 2 grades with blue stain	0	0	0	0	0	0	0	0	0	0	0	0
Total No. of boards containing brown stain	50	10	3	1	46	1	4	2	24	12	4	2
Total % of boards containing brown stain	100	20.4	6.1	2.0	93.6	2	8	4	49.0	24	8	4
Number of boards containing no stain	0	39	44	48	2	49	46	48	24	38	42	48

*Stock held in solid package one week before stickering and kiln dried.

Table 3.—EASTERN WHITE PINE BROWN STAIN FIELD TEST*

	Untreated	4 lb. Bazide	P-10-S	P-10-S plus 4 lb. Bazide	Timsan	Timsan plus 2 lb. Bazide
Downgraded 1 grade with Brown Stain	16.50	0.70	0	0	0	0
Downgraded 1 grade with Blue Stain	0	0.70	0	0	0	0
Downgraded 2 grades with Brown Stain	12.90	0	0	0	0	0
Downgraded 2 grades with Blue Stain	3.72	0	0	0	0	0
Total Dollar Loss per 1000 Board Feet	33.12	1.40	0	0	0	0

*Dollar degrade per 1,000 board feet (stock treated and placed directly in dry kiln.).

the mill. The data for the dollar degrade losses derived from brown stain were calculated on the basis of the $35 loss charged by the mill for each grade dropped in the paneling stock used in this test. Thus, if there was a 100 percent fall down of two grades from stain there would be a $70 mill loss.

Results

Table 1 shows the results for boards that went directly to the dry kiln after treatment. Eighteen of the 38 untreated controls were downgraded one grade as a result of brown stain, 7 (18.4 percent) were downgraded two grades with brown stain for a total of 65.7 percent downfall for brown stain, and 2 (5.3 percent) were downgraded two grades with blue stain. In contrast with the untreated control, the treatments (five different treatments) prevented degrade from both blue and brown stain with the exception of the 4-pound Bazide treatment in which one board (2 percent) was downgraded one grade because of brown stain, and one board (2 percent was degraded one grade with blue stain. Bazide alone exerts no blue stain control. Since this stock went directly to the dry kiln, the traces of blue stain are presumed to be log borne in origin except in the Bazide or untreated control portion, where blue and brown stain could have developed to this level during the normal manipulative period.

Table 2 shows there were 50 untreated controls. The boards in this test were solid piled one week before drying. Thirty-eight (76 percent) of the controls had blue stain but no degrade. The controls produced one board 2 percent with brown stain but no degrade. Fourteen boards (28 percent) of the controls were downgraded one grade with brown stain and 35 (70 percent) of the control boards were downgraded two grades with brown stain for a total of 100 percent development of brown stain. About 94 percent of the samples treated with Permatox 10–S alone developed brown stain, while only 49 percent of those treated with Timsan showed stain development. This ethyl mercury phosphate inhibition of stain formation is greater than that found with this system on sugar pine (1).

The increase of the Bazide level from two pounds to eight pounds per 100 gallons when Bazide alone was used caused a decrease in brown stain and thereby reduced the downgrade from 12 percent to 0 percent. There were no boards downgraded two grades with brown stain when treated with Bazide alone, while 70 percent of the untreated controls had fallen two grades.

When Permatox 10–S was used, there were 27 or 55 percent of the boards downgraded one grade with brown stain and 12 or 24.5 percent downgraded two grades with brown stain. The one board showing blue stain in both the Permatox 10–S and Timsan controls was probably from undetected log-borne stain. The brown stain dropped to the expected biological variation with the addition of Bazide to the Permatox 10–S. In fact, the Permatox solution containing two pounds of Bazide gave far better re-

Table 4.—EASTERN WHITE PINE BROWN STAIN FIELD TEST*

	Untreated	2 lb. Bazide	4 lb. Bazide	8 lb. Bazide	Permatox 10-S	P-10-S plus 1 lb. Bazide	P-10-S plus 4 lb. Bazide	P-10-S plus 8 lb. Bazide	Timsan	Timsan plus 1 lb. Bazide	Timsan plus 2 lb. Bazide	Timsan plus 4 lb. Bazide
Downgraded 1 grade with Brown stain	9.75	4.25	1.44	0	19.25	0	1.40	0.70	7.15	3.50	2.10	0
Downgraded 1 grade with Blue Stain	0	0	1.44	0	.70	0	0	0	1.40	0	0	0
Downgraded 2 grades with Brown stain	49.00	0	0	0	17.15	0	0	0	0	0	0	0
Total Dollar Loss per 1000 Board Feet	58.75	4.25	2.88	0	37.10	0	1.40	0.70	8.55	3.50	2.10	0

*Dollar degrade per 1,000 board feet (stock held in solid package one week before stickering and kiln drying).

sults than were anticipated on the basis of previous experience and must be attributed to biological factors. An 8 percent to 10 percent level of stain, insufficient to cause degrade, would have been normally expected. Since log freshness is a contributing factor, it can be argued that this was a factor in all sample groups. With the use of Timsan the number of boards downgraded one grade was 10 percent at the 1-pound of Bazide per 100-gallon level and again there were no boards downgraded two grades for brown stain. With the increase in concentration ratio of Bazide to Timsan, downgrade from brown stain was eliminated. Thus, in the Timsan portion of Table 2 the normal anticipated distribution pattern for brown stain control is followed.

Table 3 indicates that there is an appreciable dollar loss from brown stain even in stock that goes directly to the dry kiln, while Table 4 clearly indicates the amount and levels of dollar saving or increased profits that can be realized even when the stock is held in solid package for a week prior to kiln drying. In the sugar pine field test[2] these differences were even greater, although the patterns were similar.

Conclusion

This field test showed that brown stain can be eliminated with the addition of Bazide. Blue stain and brown stain can be controlled simultaneously with proper use of Permatox 10–S and Bazide or Timsan and Bazide with the resulting increase in grade recovery whether the stock goes directly to the dry kiln or whether there is a delay. Partial air seasoning with finishing in the kiln would follow this pattern. Completely air seasoned stock would be expected to show the same control pattern found previously in sugar pine except that a higher percentage of stain would be immediately apparent without an extended induction period of delayed development required by sugar pine.

Except for the untreated and Permatox 10–S controls there were no pieces dropping two grades, clearly demonstrating the effectiveness of the stain control system under these conditions. The important conclusion from Tables 3 and 4 is the increase in profit that can be realized by the use of Permatox 10–S plus 4 pounds per 100 gallons of Bazide or Timsan plus 2 pounds per 100 gallons of Bazide. As with the western pines, use of the dip system and control of solution concentration will allow sufficient time for accumulation of segregations and more nearly optimum use of the dry kiln even during the most severe portion of the stain season.

[2] Stutz, R. E. 1959. Control of brown stain in sugar pine with sodium azide. For. Prod. Jour. X(12) 459–463.

The staff at the Champlin Company is gratefully acknowledged for their cooperative assistance in the successful completion of the field test.

Holocellulose Determinations of Mountain Hemlock Bark[1]

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SINCE BARK CHEMISTRY is a relatively new field, it has not as yet developed its own quantitative procedures, but has relied on wood chemistry for its analytical methods. Although many of these methods are generally applicable, some are either partly or wholly unsatisfactory. The outstanding example of the latter is a method for isolating the total polysaccharide fraction (holocellulose) of extractive-free conifer bark. An adequate holocellulose procedure is doubly important in that not only does it provide a basic analytical value but also furnishes the cellulose fraction necessary for the study of the polysaccharides. The purpose of this study was to adapt one of the now existing holocellulose methods to a conifer bark. It was hoped that once adapted to one conifer work, it would be suitable for similar barks.

The particular bark chosen for study was that of mountain hemlock (*Tusuga mertensiana* Bongard). This bark affords a special advantage in that its physical make-up is simplified by the absence of a cork fraction, thereby enabling the study to be carried out on the "whole bark" rather than some physical constituent.

Numerous attempts have been made to isolate conifer bark holocellulose (2, 4, 5, 7, 9). All failed in that the "lignin" content of the preparations could not be reduced to that of wood holocellulose without a marked carbohydrate loss. Kiefer and Kurth[(2)] found that a pre-extraction with one percent sodium hydroxide enabled them to prepare a virtually lignin-free fraction from the bast fibers of Douglas-fir bark by either the chlorination-monoethanolamine or chlorite method. The method fails as a holocellulose procedure, however, in that the pre-extraction removed 9.3 percent of the carbohydrate material along with the constitutents that interfered with the holocellulose isolation. Although, this scheme is inadequate, it may hold the key to the successful application of wood holocellulose methods to bark. The problem was approached then with the hope of finding a pre-extraction solvent with the same beneficial action as one percent aqueous sodium hydroxide but without the simultaneous carbohydrate removal.

Experimental

The mountain hemlock bark used for investigation was ground in a Wiley mill to pass a 40-mesh sieve and extracted in accordance with TAPPI procedure T12m (8). The two extractive-free samples prepared in this manner were designated as Samples I and II.

[1] This work was performed under the supervision of E. F. Kurth, Department of Chemistry and Science Research Institute, Oregon State College, Corvallis, Ore. It was submitted as a 1960 Wood Award Entry and revised for publication in February, 1961.

Extraction of extractive-free mountain hemlock bark with one percent anhydrous ethanolic potassium hydroxide enhanced the ability of sodium chlorite-acetic acid treatments to produce a satisfactory holocellulose. The pH and time of the treatments were influential. The method was satisfactory with bast fibers of Douglas-fir bark, but not so with Douglas-fir wood chlorite holocellulose.

Attempts to prepare holocellulose from untreated extractive-free bark by the chlorination-monoethanolamine TAPPI Standard Method T9m (8) and the accepted Jayme chlorite method (1 10) proved unsatisfactory due to the large amount of "lignin" remaining in the preparations.

Pre-Extraction Study: In an effort to find a suitable pre-extention solvent, comparable alkaline extractions were performed (Table 1. The alkaline concentration of one percent was chosen in light of the work of Kiefer and Kurth (2) which revealed that one percent aqueous sodium hydroxide was the most satisfactory concentration for the removal of bark "lignin" from the bast fibers of Douglas-fir bark. This may or may not hold true for alcholic solutions.

In order to determine the amount of material other than bark "lignin" removed by the alkaline extractions, 72 percent sulfuric acid lignin determinations T13m (8) were performed on the alkaline extracted residue. This material will consist of acetyl groups, ash and carbohydrate material. The data show (Table 1) that the carbohydrate fraction of the bark is least affected by a solution of one percent potassium hydroxide in anhydrous ethanol and is, therefore, the preferred alkaline solution investigated.

Although there is no assurance that the 72 percent sulfuric acid analysis is valid for the determination of bark "lignin," it has been used repeatedly in this capacity (2, 4, 5, 7). Also it is possible that some bark "lignin" is rendered 72 percent sulfuric acid soluble by either the pre-extraction or the subsequent holocellulose analysis. Although wood lignin and the noncarbohydrate portion of bark differ radically, the term "lignin" will be used for the sake of convenience in reference to the residue, which remains after a Klason lignin analysis.

Since dioxane-hydrochloride acid had been used successfully to remove lignin from wood and bark. Sample I was extracted with dioxane containing 4 percent hydrogen chloride and 11 percent water (2, 6). The extraction removed 39.5 percent of the sample.

Holocellulose Studies: With the information gained in the foregoing study, a number of holocellulose determinations were carried out on pre-treated bark samples by means of either a modified Jayme chlorite-acetic acid method or by the chlorination-monoethanolamine procedure T9m (8).

Chlorite Holocellulose Studies: Preliminary investigation revealed that once isolated from the bark, the material removed by pre-extraction was easily attacked by a chlorite-acetic acid treatment. It was, therefore, decided not to remove the liquor from the sample when using the Jayme procedure. However, if ethanol or dioxane was involved in the pretreatment, it was removed in a stream of air before the chlorite treatments were applied.

The modified Jayme chlorite procedure was as follows. Duplicate 1.5-gram samples were refluxed with the desired solvent in a 250-milliliter Erlenmeyer flasks on a boiling water bath. At the end of the refluxing period, 160 milliliters of water, 10 drops of glacial acetic acid, and 1.5 grams of sodium chlorite were added to the flasks; additional acid was needed if the pretreatment solvent was alkaline. The loosely stoppered flasks were heated on a water bath maintained at 73 ± 1°C. for one hour, whereupon 1.5 grams of sodium chlorite and 10 drops of acetic acid were again added. These hourly additions were repeated for the desired number of times. Upon conclusion of the treatments, the contents were filtered on C-porosity, sintered-glass crucibles. Filtration was better if ethanol, instead of water, was used to transfer the holocellulose. The residue was washed with 5 percent acetic acid, water, ethanol, and ether before drying for 8 hours, at 55°C. in a vacuum oven. The results are presented in Table 2.

The data in Table 2 reveal that a pretreatment with one percent potassium hydroxide in anhydrous ethanol has a definite beneficial effect in that the residual, "lignin" content of the holocellulose is diminished to one-third the value obtained without a pretreatment. However, the reduction was accompanied by a 2 percent loss of cellulosic material. While the holocellulose still contained 2.3 percent "lignin" compared to 0.1 percent in the preparation from the one percent aqueous sodium hydroxide pretreated bark, carbohydrate loss was less than one-third of that of the latter case.

Dioxane-hydrochloric acid pretreatments proved unsatisfactory due to the excessive removal of carboyhydrates caused by the hydrolytic action of the hydrochloric acid.

Chlorination - Monoethanolamine Holocellulose Determination. The chlorination-monoethanolamine TAPPI Standard Methods T9m (8) holocellulose analysis was carried out on samples extracted with dioxane-hydrochloric acid (0.4 percent hydrogen chloride and 11 percent water) and samples extracted with a one percent solution of potassium hydroxide in anhydrous ethanol. The results shown in Table 3, are based on 12 to 15 chlorination cycles.

The data presented in Tables 2 and 3 reveal that a pretreatment with one percent anhydrous ethanolic potassium hydroxide was superior to a dioxane-hydrochloric acid pretreatment in the case af chlorite holocellulose, and that neither solvent was satisfactory when used previous to a chlorination-monoethanolamine holocellu-

Table 1.—ALKALINE EXTRACTION OF MOUNTAIN HEMLOCK BARK*

Extraction Solvent	Insoluble Residue	"Lignin" in Residue	Dissolved "Lignin"	Dissolved Other Material
Sample I				
None	100.0	52.5	---	---
1% aq. NaOH	64.3	25.0	27.5	8.2
1% NaOH in 1:1 EtOH-H_2O	73.6	33.7	18.8	7.6
1% ethanolic (95%) KOH	76.9	32.7	19.8	3.3
Sample II				
None	100.0	52.9	---	---
1% anhyd. ethanolic KOH	86.7	41.3	11.6	1.7

*Percentages based on oven-dried extractive-free bark.

Table 2.—CHLORITE HOLOCELLULOSE DETERMINATIONS OF PRETREATED BARK*

Pretreatment Solvent	Ml. of Solvent per G of Bark	Time of Extraction Hours	No. of $NaClO_2$ Treatments	Holocellulose	"Lignin" in Holocellulose	Corrected Holocellulose	Total Lignin plus Holocellulose
None†	---	---	4	54.6	6.4	48.2	101.1
Dioxane-HCl‡	50	5	4	25.7	---	-----	78.2
Dioxane-HCl‡	30	3	4	30.8	---	-----	83.3
1% aqueous NaOH†	25	1	4	37.9	0.1	37.8	90.7
1% anhydrous ethanolic KOH	25	1	4	47.9	2.3	45.6	98.1
1% anhydrous ethanolic KOH	25	1	5	44.2	---	---	96.7

*Percentages based on oven-dried, extractive-free bark.
†These two analyses were performed on Sample II (lignin content 52.9%); Sample I (lignin content 52.5%) was used for the remaining analyses.
‡0.4% hydrogen chloride and 11.0% water.

Table 3.—CHLORINATION-MONOETHANOLAMINE HOLOCELLULOSE DETERMINATIONS OF PRE-EXTRACTED M. H. BARK*

Pre-extraction Solvent	Holocellulose	Total "Lignin" plus Holocellulose
Dioxane-HCl	53.4	105.9
1% anhydrous ethanolic KOH	58.5	111.0

*Sample I.

Table 4.—ASH CORRECTION

Component	Yield*	Ash*	Ash Corrected Yield†
Bark	100.0	2.17	100.0
Klason "Lignin"	52.9	0.13	54.0
Holocellulose	45.9	0.93	46.0
"Lignin" in Holocellulose	0.9	0.17	0.7
Corrected Holocellulose	45.0	---	45.3
Total "Lignin" plus Holocellulose	97.9		99.3

*Percentages based on oven-dried, extractive-free bark.
†Percentages based on oven-dried, extractive-free, ash-free bark.

lose analysis. It was, therfore, decided to confine further work to the chlorite holocellulose analysis of mountain hemlock bark pretreated with one percent anhydrous ethanolic potassium hydroxide.

Reduction of Residual "Lignin": The residual lignin content of the chlorite holocellulose obtained from bark treated with one percent anhydrous ethanolic potasssium hydroxide was reduced one-half if the liquor was removed before the four Jayme treatments were applied. This in turn, however, reduced the yield of holocellulose by 3 percent.

Effect of Time of Contact: To alleviate the additional carbohydrate loss, a series of chlorite holocellulose determinations were carried out to ascertain the effect of the total time of the Jayme treatments. The total time of contact was reduced by decreasing one or more of the 4 one-hour chlorite treatments to one-half hour periods. Therefore, each one-half hour period substituted for a one-hour period reduced the original total time (4 hours) one-half hour.

Duplicate 1.5 gram samples were extracted in 250-milliliter Erlenmeyer flasks with one percent anhydrous ethanolic potassium hydroxide as previously described, with the exception that an oil bath maintained at 90°C. replaced the boiling water bath; this was necessary to reduce bumping during refluxing. The liquor was decanted off through an M-porosity, sintered glass crucible. The marc was then washed twice with a solution of 95 percent ethanol; the wash was removed in the same manner as the liquor. Although a water wash seemed to remove a larger portion of coloring matter, it also seemed to remove an appreciable amount of carbohydrate material. Any residue which was carried into the crucible by decantation was washed back into the Erlenmeyer flask with distilled water. Four Jayme treatments were applied as before with the exception that the first one, two, or three treatments were cut to one-half hour periods. The 160 milliliters of distilled water was preheated to the temperature of the water bath in order to eliminate the heating induction period. It was also found advantageous to heat the 5 percent acetic acid wash to approximately 80°C. to insure the removal of any precipitate that would arise from cooling during filtration of the spent chlorite-acetic acid solution. Results are shown in Figure 1. The difference between the two curves is the residual "lignin."

It is evident that a reduction in total time of contact is advantageous down to 3 hours. But below this, not only does the linearity of the time-yield function fall off, but the percentage of residue "lignin" begins to increase. Consequently, the optimum time was taken to be 3 hours; 2 one-half hour periods, followed by 2 one-hour periods. Removal of the alkaline extracted material and decrease of the "total time of contact" reduced the residual "lignin" to 1.2 percent and caused a decrease in the "corrected holocellulose" to 44 percent.

The Effect of pH: It was noted during the preceding work that the pH of the solution was 3.0 immediately after the initial addition of acetic acid and sodium chlorite, but rose to about 7.0 by the end of the fourth treatment. It seemed logical that there existed in this range some optimum pH which would have a maximum effect on the "lignin" but a minimum effect on the cellulosic material. A series of determinations were executed in buffered solutions in an attempt to prove this.

The buffers utilized were sodium acetate-acetic acid for the 4.0 to 6.0 pH range, citric acid-disodium hydrogen phosphate for pH 3.0, and a sodium hydroxide-dihydrogen phosphate buffer for pH 5.7. All pH values were measured at room temperature.

The preceding holocellulose procedure was altered in that 160 milliliters of preheated buffer solution replaced

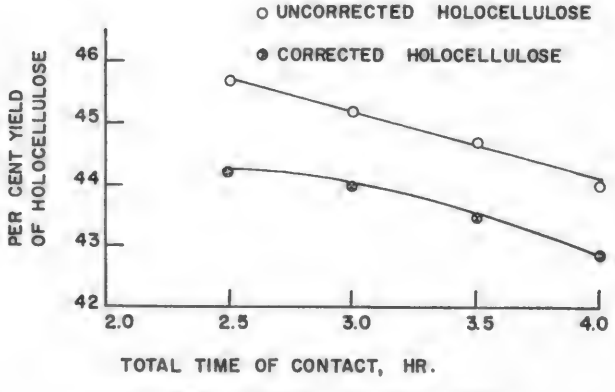

Fig. 1.—Effect of total time of contact on chlorite holocellulose yield.

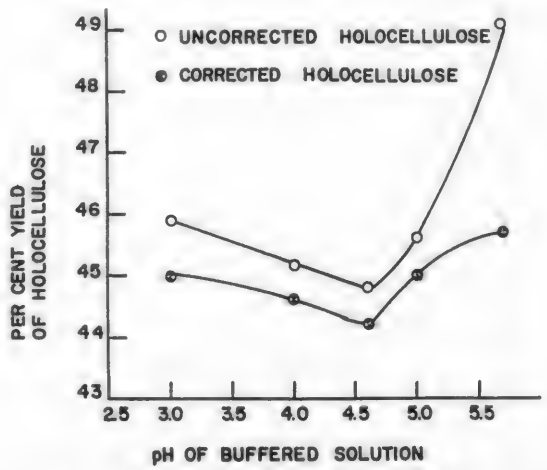

Fig. 2.—Effect of pH on yield of chlorite holocellulose.

Table 5.—HOLOCELLULOSE ANALYSIS OF DOUGLAS-FIR BAST FIBERS* AND DOUGLAS-FIR WOOD†

Component	Bast Fibers, Yield Percent	Wood, Yield Percent
Holocellulose	68.8	74.2
"Lignin" in holocellulose	0.9	1.8
Corrected holocellulose	67.9	72.4
"Klason lignin"	34.2	27.8
Total "lignin" plus holocellulose	102.1	100.2

*Percentages based on oven-dried, extractive-free fibers.
†Percentages based on oven-dried, extractive-free wood.

the 160 milliliters of preheated distilled water and acetic acid, and that no additional acid was added during the run. The times of sodium chlorite additions were those determined to be optimum from the foregoing section; 2 one-half hour periods followed by 2 one-hour periods. Results of this study appear in Figure 2.

Figure 2 shows a drastic increase in residual "lignin" incurred at pH 5.7 but the pH had little effect upon either yield of chlorite holocellulose or the amount of "lignin" remaining in the holocellulose between 3.0 and 5.0. Although the results between 3.0 and 5.0 were comparable, the reproducibility was more satisfactory in the lower pH range. The standard deviation of 12 observations at pH 5.0 was 0.67 percent for uncorrected holocellulose and 0.51 percent for corrected holocellulose. The standard deviations of 8 values at pH 3.0 was 0.36 percent uncorrected holocellulose and 0.30 percent corrected holocellulose. The greater deviation at pH 5.0 is probably explained by the fact that this pH falls on the steep side of the holocellulose yield-pH curve.

On the basis of its slightly higher value and the standard deviations mentioned, it was decided that pH 3.0 was the preferable pH. Probably any pH in the more stable region of the curve would serve as adequately. By maintaining this pH, the "lignin" in the holocellulose was reduced 0.3 percent while the value of corrected holocellulose was increased a full percentage unit (see Table 4).

When holocellulose analyses were carried out under more extensive sodium chlorite treatments, the residual "lignin" content was reduced only at the expense of the cellulosic material.

Reduction to an Ash-Free Basis: In an effort to eliminate the 2.1 percent discrepancy between the "total 'lignin' plus holocellulose" value obtained at a pH of 3.0 and 100 percent, the ash content of the extractive-free bark, Klason "lignin," holocellulose, and residual Klason "lignin" in the holocellulose was determined by the TAPPI Standard Method T15m (8). The results are presented in Table 4 along with the yields corrected to an ash-free basis. Reduction to an ash-free basis results in an extremely satisfactory "total" 'lignin' plus holocellulose" value.

This type of ash correction may seem somewhat arbitrary, but it seems logical to assume that the high ash content of bark is largely due to external causes (as dust or sand) rather than to internal causes as in the case of wood. This would mean that the majority of the mineral matter in bark is in the form of inorganic material that would remain essentially unchanged upon ashing. Consequently, the ash value obtained from bark is a good approximation of the actual inorganic content.

Analysis of Douglas-Fir Bast Fibers: To determine whether the procedure was applicable to other barks, a holocellulose analysis was carried out on the bast fibers of Douglas-fir bark. The findings are presented in Table 5.

The data in Table 5 show that the method proved quite satisfactory in that it produced a high yield of holocellulose with a low "lignin" content, but the "total 'lignin' plus holocellulose" value is not as good as that obtained from mountain hemlock bark. The fibers had a low ash content (0.5 percent), therefore no ash correction was necessary.

Analysis of Douglas-Fir Wood: A holocellulose determination was carried out on Douglas-fir wood using the procedure developed for mountain hemlock bark in an effort to ascertain its suitability to wood.

The values resulting from the aforementioned holocellulose procedure of Douglas-fir wood appear in Table 5.

This procedure seems to afford no advantage for wood over the conventional sodium chlorite method which yields a holocellulose containing from 2 percent to 4 percent lignin.

Summary

It has been shown that a pre-extraction with one percent anhydrous ethanolic potassium hydroxide greatly enhances the ability of chlorite-acetic acid treatments to produce a relatively "lignin"-free holocellulose from at least two conifer barks, but one may only speculate as to the mechanics of the enhancement. Kurth (3) proposed that the difficulty of delignification of bark fibers arises from the existence of a ligno-carbohydrate bond within the bark. This would explain the hitherto inability of the residual lignin content of chlorite, conifer bark holocellulose to be reduced below 4 percent to 6 percent without marked loss of cellulose material (2, 4, 5, 7). The breaking of this bond could well explain the beneficial action of pre-extraction with alkaline solution.

When the acetyl content of Sample II (0.5 percent) is added to the "total 'lignin' plus holocellulose" value in Table 4, 99.8 percent of the extractive-free, ash-free bark is accounted for. This connotes little removal of carbohydrates by the pre-extraction.

The procedure developed for the isolation of mountain hemlock bark holocellulose did not reduce the residual lignin content of Douglas-fir wood chlorite holocellulose. However, the "total 'lignin' plus holocellulose" value indicates that little effect is incurred on the holocellulose by the pre-extraction.

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Business Education and the Forest Industries[1]

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MOST INDUSTRIES ARE INCREASING their contributions to education. The basic reason for the increase is that investment in education pays a return equal to, or greater than, the alternative of current plant investment; the generosity is a result of practical thinking. In 1958, 28 of America's larger companies contributed one percent, or more of net income before taxes to education.[1] The survey of the Council of Financial Aid to Education disclosed an average gift or contribution to be $138,555 (not contract research) from 352 respondents. Of the larger donors (either in percentage or dollars given), none were in the forest industries (including pulp and paper). In primary metals, 5 firms gave over 5 percent of net income before taxes; of 23 industrial categories in the order of donation, lumber and wood was twenty-first (0.23 percent of net income), pulp and paper twenty-secondth (0.22 percent).[2] A Harvard study in 1952 determined that research expenditures in the wood industry were 0.2 percent of product value; for lumber only, research expenditure was 0.08 percent of product value. The national average for drugs, by contrast, was 39 times as great; even the paint manufacturers spent 24 times as much.[3]

To do the same things in the same way, may have been adequate for growth and survival in the past. It is not possible in the forest industries today. The prizes go to the creative and original thinkers—to the ones with initiative to adapt revolutionary ideas to conventional processes—including all the routines of business management. Despite the fine record of achievement in technical research, more can and must be done.

It is natural to resist appeals to support basic research and educational programs. (It is common enough even in technical areas let alone in business education.) The time of reward is too remote and indefinite; results are often intangible; there are few standards by which to judge research performance. Moreover, the principal product of a research staff is FAILURE. Research is a continuous process of experimentation and rejection. For example, over 40,000 substances have been tested in the search for a chemical that will halt the explosive growth of cancer cells; but no one would seriously recommend stopping the search. The advances made possible by a rare breakthrough make the total cost seem small by comparison.

It is a wonderful, fascinating world in which we live, the product of a literate society and free, mass education. The guarantee of education to all citizens is characterized as the noblest act of any government ever in history. A failure to support research and education by the forest industries is to forsake any right to criticize the processes and objectives of our universities and colleges. The one who pays the fiddler, calls the tune. If the sole, or major source of funds is from the government, or from one's competitors, they will rightfully determine the amount and the kind of research and teaching activity of our institutions.

In non-technical areas, the forest industries, by and large, do not obtain the best-trained persons—either in research or in business administration. Our most outstanding graduates are not consistently solicited and encouraged to enter the industry. Full-time recruiters from America's largest companies skim the cream of our professional school graduates in accounting, marketing, finance, production, transportation, insurance, and management. Any industry that does not aggressively court talented young potential executives and administrators will find itself in competition with these same people who will be working for another company.

Managers have a responsibility to effect changes of all sorts. We hear a great deal about the "dynamic American economy"; yet, in many segments of the lumber industry, the apparent byword is "don't rock the boat." The seeds of decline and destruction of an industry exist within its structure if it is resistant to change; if it is unwilling to become a part of new, progressive management technology; and if it is reluctant to raise questions about executive capability, the quality of decisions, appropriate company goals, or community responsibility.

We are on the threshold of another industrial revolution, and the slow, the cautious, the untrained, and the unimaginative will be left behind. Notwithstanding all of the great accomplishments of the last 300 years in power, transportation, communication, engineering, and production technology, the greatest and most revolutionary accomplishments are yet to come. Think of this: More than 90 percent of all the scientists and engineers who have ever existed are still alive and working today.[4] Their out-

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The wood industry in general cannot do basic research and, in many cases, not even applied. The business school represents a reserve pool of researchers and specialists in accounting, marketing, production, and finance. Industrial association with educational institutions is inevitably advantageous, as outlined in this report.

p[illegible] and the ramifications of their re-s[illegible]rch will require a prodigious effort o[illegible] the part of every manager to un-d[illegible]stand, to plan for, to utilize, to re-a[illegible] to the new situations. These people d[illegible]velop new tools, products, methods, u[illegible]derstandings, and sources of energy – all of which mean, new PROB-I[illegible]MS to solve. We are certainly no l[illegible]nger masters of our fate, if we ever w[illegible]re. We are involved in a universal c[illegible]ntest where the initiative for change n[illegible]y not be ours, where we may be f[illegible]rced to adjust to all manner of ex-t[illegible]nal pressures.[5] We have, at our dis-p[illegible]sal, a two-edged sword; it can cut f[illegible]r us or against us. If it is properly directed and controlled, this tide of technology will be constructive and a source of tremendous power; used unwisely, it may be destructive, and we may be drowned in the flood of our own inventiveness.

Business Problems of the Forest Industries

A few broad problems of industry in which business school researchers are, or would be, interested are:

1. To insure the acceptance of wood products. Why do consumer tastes and attitudes change? Can these changes be measured, anticipated, and predicted? With new substitutes for wood fiber, does the answer lie in new products of wood, or only more aggressive merchandising of old? How should the industry respond to the challenge of a single competitor who spends more on research and promotion for one product than the lumber industry spends in promoting all its products?

2. To plan an effective production and sales program in the face of diminishing top-quality raw materials. It is true we do not have to search for trees (as oil refiners must search for oil); however, we have less control of raw material supply than other industries do. Beyond this, the wood industry, except for paper, also has the difficult task of stimulating a demand, if only because of the large number of merchants whose efforts need to be coordinated. Lumbermen struggle for a larger individual share of the pie; but the pie shrinks rather than expands.

3. To cope with the problem which results from a severe cost squeeze. The wood industry faces rising supply prices of stumpage and, at the same time, is at the mercy of uncontrollable price swings of the final market. Although the demand for lumber and plywood is derived primarily from the demand for houses, there is a great price distortion when there are relatively small changes in consumption. Under these circumstances, a merchant can have no price policy.

4. To explore definitely the problems of taxation. The revenue needs of state and local governments are totally unrelated to investment and profit opportunities in wood processing. Even with the best business planning and good forest management, gains may be removed by legislative fiat.

5. The increasingly important problem of shrinkage of the land available to grow trees. There is growing pressure for primitive and wilderness areas, need for more arable farm land, plus the clearing necessary for homes, highways, dams, and other purposes.[6] Yet, with the magnification of these pressures by the population explosion, as it is called, the industry is expected to produce more on a smaller base.

6. Regional problems for the industry in both production and marketing. With higher average wage costs (relative to other producing areas), higher transport costs (as a percentage of final prices), higher taxes, and higher stumpage prices, the Northwest also faces serious foreign competition. On top of this, with the increasing population of the western states and visits by eastern tourists, there is more demand for recreation, water, game, fish, and range land. Even Solomon would have difficulty trying to solve this one.

7. The problem of greater capital investment to process low-value waste material. This is a problem of the wood industry's own creation. Although it is reasonable and desirable to try to get more dollars of salable product from each log, each new product requires ever greater capital investment for the processing of low-value materials. In addition, large expenditures are necessary to develop new markets for laboratory items which must be tested, packaged, delivered, promoted, priced, and, hopefully, sold at a profit. Unfortunately, some of these products merely displace the market for other wood products.

In sum, many of the critical, current industrial issues are business problems, wholly or partially. The need for research in management techniques and marketing activities in the industry is already great and will become greater. With each job promotion and increase of responsibility, all executives, including the technical specialists, become proportionately more concerned with administrative, personnel, and broad policy-making functions. Finally, to compete effectively for the indispensable human resources that exercise judgment in all processes, the industry must participate in and support research and teaching programs in business education. It is through this means that the best minds will respond.

The industry cannot risk the uncertain chance that graduate students and faculty may begin, on their own initiative, the investigations that will be of ultimate benefit to the industry. Research people are more likely to be interested in the forest industries if these firms show some interest and concern in the direction their work takes.

What Business Schools Can Do

A business school faculty amounts to a reserve pool of skilled teachers, researchers, and men of broad industrial experience. Such a group can provide a low-cost, unified approach to consulting and research; it can function effectively in an investigation of the problems of a single firm or species, a region, an industry, or the problems of an association. Such a group of specialists in accounting, marketing, production, finance, and so on, is flexible; staff members can function cooperatively with industry personnel, outside consultants, or faculty from other schools. One would be associated with a stable, reliable group with high professional reputations.

Some of the studies which could be explored are: foreign competition in raw materials, end products and equipment, documentation of conflicting claims, and policy recommendations for government and industry; current and future state and local tax revenues under several timber-cutting policies, and tax change proposals to guide industrial policy and to restrain political opportunists; and the capital markets of the Northwest, the sources and flows of funds into investment, access problems and costs of borrowing, to determine what can (and

must) be done to alleviate financial pressure on mills.

One could explore also labor productivity which would either document or challenge the conflicting explanations of rising lumber prices (compared with other construction materials), a study of rising stumpage prices in terms of conventional theory with careful attention to local factors; employment history and labor usage to develop methods and techniques to forecast levels of employment, to aid state and industry planning for training, and to anticipate technological displacement; and land use in selected communities, the changing environment for business, transportation and industrial development as a guide for private investment decisions.

Other studies could be measurement of the dollar value of the forest industries to a region or state which would include primary processing and secondary, indirect activities, the calculation of an array of revenue and expenditure flows; and interregional competition in lumber production and sales by major U. S. areas, a linear programming model to isolate and manipulate various factors that influence strategy and tactics in merchandising, and to explain the patterns of production and distribution activities.

There are many more topics that could be mentioned. The new 1620 electronic computer at our university will permit basic or applied research in production scheduling, sales forecasting, records analysis, mechanization of routine procedures, or inventory planning. My own special interest is marketing. A thorough study of the chaotic plywood market would be a challenging and rewarding investigation meritorious of the entire industry's support. A serious problem for the forest products industries is that in many critical areas we have not taken the first steps in analysis, i.e., the bench mark studies where things are counted and classified by various characteristics.

With only a few exceptions, none of the forest industrial companies which operate in the Northwest are able to do much basic research, especially in non-technical areas; the majority perhaps cannot effectively do applied research of real magnitude. Few can afford a trained research staff since such a staff cannot be used all the time. One solution is to investigate the opportunity of associating with an educational institution in order to consult, in a stimulating environment, with competent specialists whose services can be obtained periodically as needed.

What Industry Can Do

The industry can provide encouragement in a variety of ways, the most important of which is financial support. Half of the research in the U. S. today is supported by the federal government. It is crowding out many private organizations in its successful bidding for the best research people.

The industry can offer scholarships, fellowships, prizes, endowments, trusts, bequests and outright gifts of money and realty. The choice to do this has always been present, and when it has been exercised, the results have been significant. I submit that it is possible to obtain full, direct, and immediate value in exchange for financial outlays which support the processes of education. Contract research of the sort previously described is a straight-forward business transaction with measurable results. A share should also be allocated for basic or pure research. In addition, many companies can help train prospective industrial employees by offering part-time or summer jobs to qualified, non-technical students. Executives may make themselves available as speakers and discussion leaders before classes, seminars, and in executive development programs. They will, thereby, encourage university study of business administration and economics as appropriate training for employment in the industry. To bring the problems and inquiries of the industry to university campuses will stimulate the faculty to develop ideas and interest; it will facilitate reciprocal communication.

There will be some opinion that although it is logical to support a private school, there is no need to provide funds to a state institution. If industrial leaders believe that their obligation to a state educational system is met with the payment of taxes, they are, in effect, subrogating to the legislature the privilege to influence and determine the quality of public higher education. With respect to quality, it is unfortunate that budgets for higher education are, of necessity, set at levels to provide for an adequate physical plant and the salaries and wages of employees. The little extra, the margin for excellence, the activities that produce earned prestige and national recognition usually come from outside the tax receipts. State legislatures only create the potential for outstanding performance; outside support will make it possible. The University of California, for example, spent $249 million in 1957–58; of this sum, only $84 million (one-third) was supplied by the state. Only 5 percent of that university's formal research is supported by state funds (7). If you support the schools in your state, or your alma mater, or any institution of higher learning, however selected, you benefit all of society. Ultimately, everyone is served by the contributions of educated people. It is to the educated people, to those who best know the values of education, indeed those who have most benefited from it, that society looks for assistance.

One may object that research for its own sake is not desirable, since some may be poor, and some may simply be redundant. This is true, but it is a calculated risk we must take. There is always an excess of poor research, and there can never be enough good research; but the results of research cannot be evaluated until they exist. No group can assist in the solution of the problems of the forest industries without the support of those industries. Competitors of the forest industries are engaged in a program designed to displace wood fiber in 50 percent of U. S. homes by 1975.

Schools of business do not promise to create executives of the students they develop. We do teach a young man executive procedures and give him practice in the use of his judgment, even to simulation exercises in management games where his decisions may be evaluated. However, whether he becomes an executive in fact is determined by encouragement, opportunity, and his personal motivation. We try to develop an inquiring mind, the ability to think logically and independently, and the capacity to make decisions unencumbered by dogma and the dead hand of tradition. We believe, perhaps immodestly, that we are on the right track and are making progress; however, our objectives, research, and potential workers need help. The responsibility of the lumber industry is clear. The opportunity for progress and growth exists, but it will not just happen. It must be recognized and supported.

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Variation of Wood Properties

IN SOUTHERN RED OAK

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Many trees that are now utilized only for low-value end products contain wood suitable for many of the high-value processes. Lack of data on specific properties and characteristics has prevented the wise and efficient utilization of these species. This study shows how various properties of southern red oak form definite patterns as the tree develops. These patterns are related to ultimate properties of the wood.

THE VARIATION OF WOOD PROPERTIES within trees have been the subject of academic investigation for almost a century. Only recently has intensive utilization of timber and knowledge of the importance of physical and anatomical characteristics of wood in the performance of manufactured goods given this variability practical significance.

Many tree species, that are used for low-value products, contain wood which is desirable in many respects for higher-value processes but are not used because specific knowledge of their characteristics is inadequate. As part of a program to encourage the use of a low value species in a utilization process a determination of the variation of certain wood properties of southern red oak (*Quercus falcata* Michx.) was undertaken. This paper presents the results from a larger study of variation in southern red oak, which relate to the patterns in individual stems of the following selected wood properties: specific gravity, percentage of latewood, side hardness, toughness, fiber length, and percentage of the transverse surface in supporting tissue.

Procedure

Six southern red oaks were selected from two mixed hardwood-pine stands of the Hill Demonstration Forest of the North Carolina State College in Durham County, North Carolina. All trees selected were: 1) at least 12 inches in d.b.h.; 2) dominant or codominant; 3) free of visible defects, 4) without crook, sweep, or lean; 5) from stands with approximately equivalent basal areas; and 6) representative of the extremes of local site conditions.

Selected trees were sampled by dividing the bole into segments, such segments, each equal in length to 10 percent of tree height. Beginning at stump height, and at the base of succeeding segments, bolts 2 feet in length were removed from the trees. This provided a mechanical sample of 10 bolts from each tree. Four one-inch boards, two flanking the longest radius and two flanking the shortest radius, were cut from the bolts for critical measurements.

Beginning at the next to the last annual ring from the bark (the last ring was omitted since it may not have been a complete ring), successive 10-year increments were delineated on both the transverse and radial surfaces of the sample boards. These 10-year increments were the basic units used in all laboratory analyses, and the various wood properties were determined on each or a combination of two or more adjacent units from two sample boards—one flanking the longest radius, and one flanking the shortest radius. Test results from the two radii at each height were combined by averaging.

Depending on the specific laboratory analyses to be performed, sample material was either preserved in the fresh condition or dried to the proper moisture content by exposure to successively smaller E. M. C. (Equilibrium Moisture Content) conditions. Specific gravity of unextracted samples was based on oven-dry weight and volume. Tissue areas were determined by a photo-optical method (7).[2] The remaining laboratory analyses were performed according to standard A.S.T.M. procedures.

As a result of the sampling procedures, the location of each sampling unit could be defined in terms of a percentage of total height and age from the center of the tree. Graphical analysis of the data indicated the most suitable statisical treatment to be a multiple regression analysis and the fitting of a regression equation in terms of height and age, the squares of each, and the cross-product. Thus a quadratic equation was derived for each property in each tree. In this manner the variation of the properties, associated with location in the stem, was defined for each tree by a second order polynomial equation. A generalized mathematical expression for each wood property was obtained by averaging the individual tree regressions.

Results

Physical Properties: The highest specific gravities were found in the

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[2] Numbers in parentheses refer to Literature Cited at the end of this report.

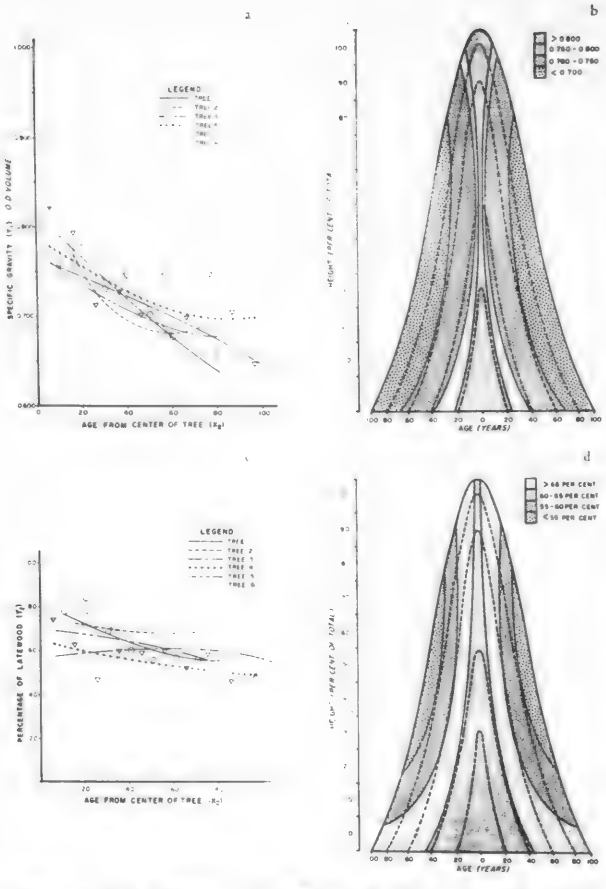

Fig. 1.—The variation in specific gravity and percentage of latewood along the lowest radii samples (a — c) and for an average tree (b — d).

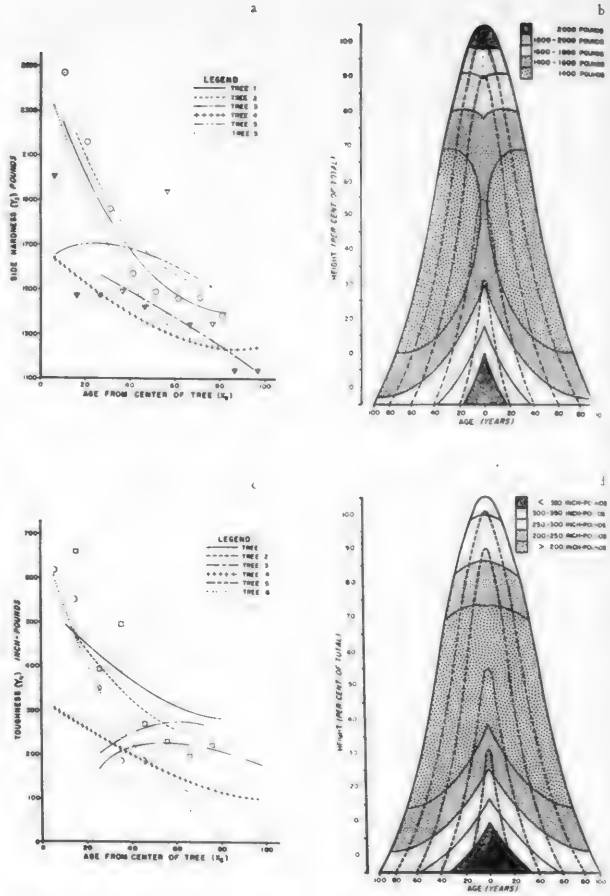

Fig. 2.—The variation in side hardness and toughness along the lowest radii sampled (a — c) and for an average tree (a — d).

center of each of the trees examined. Values as high as 0.896 were recorded. Along radii extending outward from the center, at all height levels, there was a marked decrease in specific gravity at successively greater distances. These relationships are shown (for the lowest height level) in Figure 1–a. The slope and degree of curvature were similar for each of the six sample trees. The rate of change associated with this inverse relationship between specific gravity and age diminished in all trees but one, which conversely exhibited an increasing rate of change with age. When individual trees are considered, the least dense wood was not always located in the peripheral regions of the bole but in certain instances was reached at a point nearer the center.

When all trees are considered without regard to sample location, the maximum specific gravity determined was 0.896 and the minimum was 0.549. These two values were not derived from the same tree. The tree that contained wood with most density also contained wood of 0.641 density, and the tree containing the least dense wood produced wood with a density of 0.850. The maximum range between trees was 0.347 compared to a range of 0.301 within trees.

The plotting of individual points about two of the regressions (Figure 1–a) indicates the degree of variation encountered and the goodness of fit of the second order polynomials. The scatter of the points about the regressions varied from tree to tree. The scatter about Tree 1 is not great, and there was more variation about the regression for Tree 4. Regressions were fitted to the data from the whole tree, not only for the lowest height level, and contributed to this point scatter.

The average pattern described by specific gravity (Y_1) variations within a tree is expressed mathematically in the table. The equation for Y_1 indicates an inverse relationship between specific gravity and both height and age. The multiple correlation coefficient (R) of 0.748 suggests that 56 percent of the observed variation in specific gravity was accounted for by the average regression, which is illustrated by a topographic section (Figure 1-b). In the average tree there is a central core of high density wood (greater than 0.800) which extends the length of the bole. Surrounding this are cylinders of successively less dense wood. The peripheral regions of the bole contain wood that ranges between 0.650 and 0.700 in density. The thickness of the central core and its surrounding cylinders are a function of height.

Latewood percentage varied with age (Figure 1–c) in a manner somewhat similar to specific gravity. Five trees contain wood with a higher percentage of latewood in the center than at any other point, and one tree produced maximum latewood at approximately 70 years of age. Here again, most trees exhibited decreasing percentages of latewood with age, and the lease latewood was not always located in the peripheral regions. The maximum and minimum percentages of latewood which occurred in any of the six trees were 88.0 percent and 36.9 percent, or a range of 51.1 percent between trees, without regard to sample locations. Immediately adjacent to the sampling point with the least percentage of latewood were sections with as much as 69.3 percent latewood. Thus, even between adjacent sampling

points within the same tree, a variation of 32.4 percent occurred. There was less variation of the individual points about the regression for this property than for specific gravity, as indicated by the scatter of points in Figure 1–c.

In the average expressions (Table 1) the percentage of latewood (Y_2) was inversely related to height and age with a positive curvature. An R value of 0.753 revealed that 56.7 percent of the variation in percentage of latewood was associated with the regression equation. Contours of equal percentages of latewood (Figure 1–d) approximated those of specific gravity for there was a central core of wood with a high percentage of latewood surrounded by cylinders of wood with successively less latewood.

Mechanical Properties: Side hardness (Y_3) and toughness (Y_4) were greatest in the center of most trees examined and in general varied with height and age in a similar manner in each tree. The variability along the lowest radii is presented graphically (Figure 2–a and 2–c). Three of the trees contained wood which was relatively high in both hardness and toughness in the center but decreased rapidly with age; while a fourth tree exhibited the same hardness pattern, but was not as strong in the center. The rate of change in both properties decreased with increasing age. The remaining trees did not conform to these patterns but exhibited a direct relationship with age combined with a decreasing rate of change.

The variation about the individual tree regressions is indicated by the scatter of individual data points (Figure 2–a and 2–c). The extent of the variation differed from tree to tree. When maximum side hardnesses recorded in each tree are compared the greatest difference between trees was 550 pounds. On the other hand when only the within-tree variation is considered a difference of 1,387 pounds was observed. Toughness was also extremely variable having approximately the same range as side hardness.

Within the average tree, as described by the regressions (Table 1) and the topographic sections (Figure 2–b and 2–d), the hardest and toughest wood was located in the lower and upper bole regions. The middle of the bole was largely composed of wood having the least degree of side hardness and toughness and lacked a central core of high strength wood extending the length of the bole. When the entire average bole is considered, side hardness ranged between 1,200 and 1,200 pounds and that of toughness was between 400 and 150 inch-pounds. The coefficients of determination indicated that the average regression accounted for 61.5 percent and 56.6 percent of the observed variation in side hardness and toughness.

Anatomical Characteristics: Fiber length (Y_5) exhibited less variability between trees than did any of the other wood properties (Figure 3–a). In all trees, fibers were shorter in the center than at any other point on the radius. Along any given radius, the fibers gradually increased in length for a period of time, which varied to some extent between trees. The slopes of the regressions were nearly the same for each of the six trees indicating the same general pattern. Minimum fiber length in any one tree was 1.30 mm.; in this same tree, fibers as long as 1.52 mm. were also observed. This was the maximum within-tree range. If within-tree location is ignored, the minimum fiber length in each of the six trees varied by 0.20 mm. Approximately the same range (0.24 mm.) occurred in maximum fiber lengths. The scatter of the individual points about the regressions suggests that the fitted curve for fiber length was a good estimator of the observed variation. This point scatter was less than for any other property.

The topographic section (Figure 3-b) constructed from the average regression (Table 1) demonstrated that the average tree is characterized by a central core of wood of uniform width containing fibers less than 1.10 mm. in length which extends the length of the tree. Immediately surrounding this area is a uniformly narrow shell with fibers ranging from 1.10 mm. to 1.50 mm. Outside this shell, the fibers were longer than 1.50 mm. but less than 1.90 mm. The average regression accounted for 75.4 percent of the variation observed in fiber length.

Apparently height only slightly affects fiber length. Along a radius at any given height level, the most rapid increase in fiber length occurred during a relatively short distance near the center of the tree. Following this, the rate of increase was reduced markedly.

The other anatomical characteristic reported is the proportion of the latewood increment composed of fibrous and related tissues (Y_6). Except for Trees 3 and 6, little variation occurred between trees in this tissue (Figure 3–c). In all trees, the greatest amount of latewood fibrous tissue was found in the center. As with the other properties, more within-tree variation than between-tree variation occurred.

On the average (Table 1 and Figure 3–d), the percentage of latewood fibrous tissue assumed a configuration different from the other properties. Areas of equal percentages of this tissue formed a series of cones with the greatest amount—more than 40 percent—located in the base of the tree. The entire upper portion of the tree contained latewood composed of less than 20 percent fibrous tissue. The quadratic equation employed to describe this variation accounted for 51.7 percent of the observed variation and, thus, was less efficient for this property than for the others.

Discussion

Variation with Location in the Bole: These results indicate that certain properties of southern red oak vary not only between individual trees in a stand but also within tree boles. This intra-bolar variation may exceed the between-tree variation. Some within-tree variation follows an orderly sequence associated with position in the bole, but possesses an additional component which is apparently random.

Wood with the highest density and the greatest percentage of latewood was found in a central core extending the length of the tree. This core was surrounded by shells of wood of lower specific gravity and lower percentage of latewood (Figures 1–b, 1–d). The diametrical width of this core and the encompassing shells were more or less a function of height. These findings are in agreement with earlier studies in ring porous hardwoods (9, 10). The increase in diameter of the central core of dense wood in the upper bole portions has not been generally recognized. That such a phenomenon may occur has been confirmed by Paul (10).

Mechanical properties varied with location in a manner analogous to that of the physical properties. Wood with the greatest side hardness and toughness was located in the upper and lower portions of the bole. Wood from

AVERAGE REGRESSION EQUATIONS, THEIR MULTIPLE CORRELATION COEFFICIENTS, AND COEFFICIENTS OF DETERMINATION

Dependent Variable	Independent Variables	R	R^2
Y_1	$=0.8474-0.0263x_1-0.0034x_2+0.002035x^2{}_1+0.000018x^2{}_2+0.000036x_1x_2$	0.748	0.560
Y_2	$=75.874-1.7387x_1-0.3598x_2+0.1510410x^2{}_1+0.002818x^2{}_2-0.035910x_1x_2$	0.753	0.567
Y_3	$=2423.2-334.3x_1-22.45x_2+28.4072x^2{}_1+0.166976x^2{}_2+1.993817x_1x_2$	0.784	0.615
Y_4	$=472.2-98.22x_1-4.444x_2+8.14833x^2{}_1+0.026078x^2{}_2+0.524580x_1x_2$	0.752	0.566
Y_5	$=0.9907+0.0861x_1+0.0150x_2-0.007752x^2{}_1-0.000105x^2{}_2-0.000801x_1x_2$	0.856	0.754
Y_6	$=52.42-6.822x_1-0.3008x_2+0.227832x^2{}_1+0.0012222x^2{}_2-0.012368x_1x_2$	0.719	0.517

Y_1 = specific gravity
Y_2 = percentage of latewood
Y_3 = side hardness
Y_4 = toughness
Y_5 = fiber length
Y_6 = percentage of latewood fibrous tissue
x_1 = percent of total height coded by $\left(\frac{1}{10}\right)$
x_2 = age from center of tree

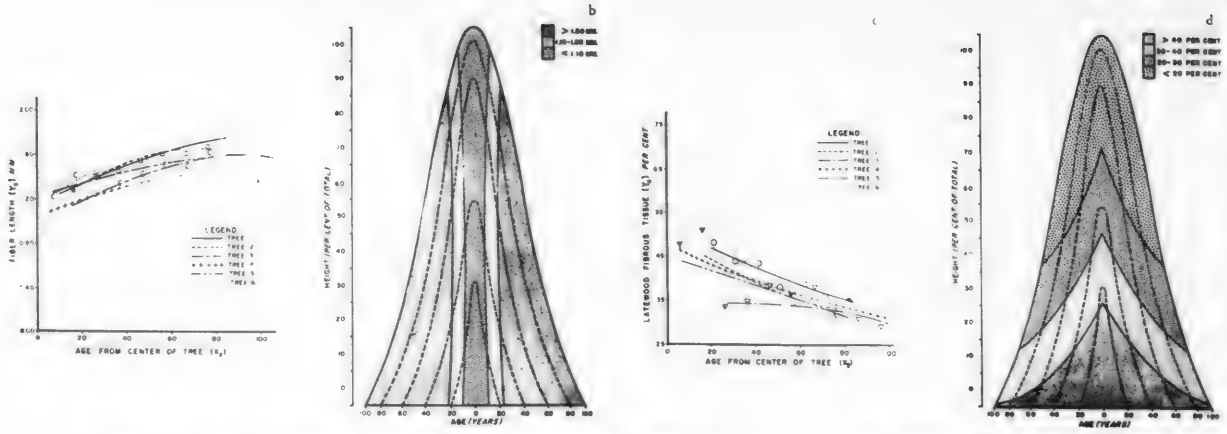

Fig. 3.—The variation in fiber length and percentage of latewood fibrous tissue along the lowest radii sampled (a — c) and for an average tree (b — d).

the mid-heights offered the least resistance to indentation and was the least tough.

While the literature is not replete with references to studies of this nature an insight may be gained through results presented by Sterrett (13), Myer (9), Clarke (5), and Koehler (8). In English ash, Clarke found the toughest wood to occur in the butt of the trees studied. These findings corroborated an earlier report by Sterrett for ash from this country. Koehler, while discussing brashness in ring porous woods, mentioned a locational effect and pointed out that wood with the least degree of brashness occurred in the lower bole. Myer observed a position effect on a mechanical property in white oak.

These data from southern red oak illustrate a phenomenon not observed by earlier investigators, i.e. wood equal in toughness to that in the base of the trees occurred in the uppermost bole portions.

Variation in mechanical properties along a radius at any specific height has received little attention, although Koehler (8) concluded that no consistent relationship existed between toughness and distance from the pith. Such an effect was observed, however, in southern red oak. Specific gravity, at least in ring porous hardwoods, is a function of distance from the center (9, 10); and according to Koehler (8) a direct (if somewhat tenuous) relationship exists between specific gravity and toughness. Thus, if specific gravity varies along a radius, at least some variation should occur in toughness and side hardness. The interest of previous investigators in the variation of minute features with position in angiosperms has been confined largely to the length and diameter of various vertical cells. Even in this area of investigation coniferous species have received much more attention. Sanio (12), Gerry (6), and Bethel (2) conclude that coniferous tracheids increase in length with increasing distance from the center, at least during the early life of the trees. A similar relationship probably holds true for angiosperms (1, 4, 11). This general relationship was found to hold true for fibers in southern red oak. The major point of disagreement among previous investigators has been the duration of the period of rapid increase. The data from southern red oak indicate that the length of this period varies between individual trees (Figure 3–a) and may have a genetic basis.

Although wood quality is a function of many wood properties, only a relatively small amount of research has been devoted to the direct investigation of tissue quality and how this quality varies with location within the bole. The data from this study suggest that the formation and grouping of the fibrous elements in southern red oak follow definite patterns.

Interrelationship Between Wood Properties

The contour diagrams provide a means for making qualitative comparisons, on a whole tree basis, between the several wood characteristics. That the physical properties of southern red oak are related directly or through a common factor is demonstrated by a comparison of their contour graphs. For example, if Figure 1–b is compared with Figure 1–d, it will be seen that although the areas of the tree with low specific gravity do not exactly coincide with areas of low latewood percentage, and vice versa, when the entire tree bole is considered, there is apparently a distinct positive relationship between these two properties. The existence of a clear relationship in all ring porous woods is uncertain, for Clarke (5) was unable to conclude that percentage of latewood and specific gravity in ash were related. Instead, the quality (proportion of supporting to conductive tissue and cell wall thickness) of latewood tissue was thought to be more important. Bethel (3), however, found a high degree of correlation between specific gravity and the percentage of latewood in young chestnut oak (*Q. montana* Willd.) wood. Southern red oak, on the average, exhibited a relationship between the percentage of latewood and specific gravity similar to that observed in chestnut oak.

These data provide an opportunity to qualitatively examine a portion of the thesis advanced by Clarke (5), that the amount of supporting tissues, together with cell wall thickness in the latewood were important contributory factors to variations in density. The percentage of the transverse surface composed of latewood fibrous tissue is a measure of the amount of supporting tissue of interest to Clarke. Comparison of Figure 1–b with Figure 3–d indicates that specific gravity and this tissue are not closely correlated when the entire southern red oak tree is considered. If this relationship is examined on an individual tree basis by comparing Figures 1–a and 3–c, closer relationships may be observed. Tree 6, for example, contained denser wood in the center than any other tree, while at this location the greatest percentage of supporting tissue was also observed in this tree. At greater distances from the center in Tree 6, there was a rapid decline in each of these properties. Almost as good a relationship was found in Trees 1, 4, and 5, but the relationship in the remaining trees is not as well defined.

This is an illustration of a point that should be made, which probably accounts for some of the contradiction in

studies of this nature. The interrelationship between various wood properties and even the patterns assumed by wood properties is, at least in part, a function of the individual tree and may be quite variable in different trees.

Summary and Conclusions

This study indicates that various properties of southern red oak wood form definite patterns during the development of the tree. Because of this positional effect, wood from the central portion of the bole possesses many desirable characteristics in contrast to wood at the periphery. Since wood at the center of the tree was denser, harder, and tougher than that produced in later years, it may be desirable to grow southern red oak on short rotations.

These data support the contention that density of ring porous hardwoods is closely related to the percentage of latewood in the annual ring. The theory that the quality of the tissues in the latewood band bears a strong relationship to specific gravity is supported to a limited degree by these data. The mechanical properties were more closely related to specific gravity and percentage of latewood than to the quality of the latewood tissues.

Specific gravity, percentage of latewood, side hardness, toughness and the percentage of latewood fibrous tissue were inversely related to both height in the tree bole and age from the center. Fiber length was directly related to height and age. Regression equations are given which define the variation found in the stems.

Even between sites in close proximity, there existed some between-tree variation but a larger amount of variation was observed in most instances within individual trees.

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Determination of Member Stresses in Wood Trusses with Rigid Joints

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Abstract: The use of wood trusses has become increasingly common in the American small building industry. Construction economics and improved performance have both been driving forces behind the ever increasing adoption of these prefabricated units. With this interest have come innovations in methods and materials for joining the members. Some of the more popular of these produce joints that are, for all practical purposes, rigid. While the introduction of joint rigidity has improved general performance through the rigidity itself and over-all increased joint strength, the engineers job of design has been further complicated.

All but the simplest rigid jointed structures are indeterminate and, consequently, more difficult to analyz- The situation is further complicated because wood truss joints are usually relatively bulky in relation to member spans and are often eccentric for architectural or economic reasons. Full scale destructive tests of wood trusses show clearly by the patterens of deformation, strength of structure and type of failures that conventional methods of truss analysis are not realistic.

A method based on standard principles of structural engineering has been developed to cope with the specific problems presented by wood trusses and frames. The procedure seems, at first, to be overly extensive for such small structures but is seen to be more appropriate when it is realized that even a simple W pattern truss bearing symmetric loads requires the determination of 22 unknowns for a complete members analysis. Accurate joint design without knowledge of these unknowns is impossible—with joint rigidity, moment stresses assume prime importance.

The truss is broken into sections consisting of members and joints. First estimates of axial forces are obtained by conventional means and used in estimating relative end displacements due to truss deformation. Slope-deflection equations are written for each joint including the effects of eccentricity and shears at the joint faces along with end displacement terms from the previous computation. Solution of these equations yields moments and shears on the joints which are, in turn, used to obtain revised estimates of member forces.

The procedure was evaluated with an experimental program. Theoretical stresses for the two trusses were found to be in satisfactory agreement with experimental stresses obtained through the use of electric strain gages on the same trusses. Theoretical and measured deflections of lower chords of one truss type and five copies of another type were also in good agreement.

The procedure may find practical use as a standard for validating shorter approximate methods for specific truss types, loads and spans. Automatic computing equipment, to which the method seems adaptable, can produce more accurate designs of infinite variety. The research worker may find the procedure useful in devising more efficient truss patterns and proportions. Joint design can become more precise through knowledge of the moments and forces that must be resisted.

A copy of this publication, Research Bulletin No. 714, can be obtained free upon request from the Mailing Room, Agricultural Experiment Station, Purdue University, Lafayette Indiana.

Linear Programming in Lumber Production

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Last January, the FOREST PRODUCTS JOURNAL carried a mathematical analysis designed to show the logger how to make the most money out of the tree. Here's the next step—a technique for determining the optimum combination of lumber sizes to cut from each log. Objective: efficient utilization and maximum profit.

ONE OF THE PRIMARY FACTORS that should be considered in improving the operation of a small sawmill is whether or not the logs are being utilized in the most profitable manner. From a given size log there are many combinations of lumber dimensions that can be produced. If market requirements were unlimited for each of the lumber sizes, the problem could be solved by simply determining the most profitable way of sawing each of the different log sizes and producing everything in this manner. In very few instances is such the case, however, since some lumber sizes are in great demand and others have a very limited market. Because of these market limitations, the problem becomes one of sawing the log in the most profitable manner consistent with the restrictions imposed by the market demand for various lumber sizes. The purpose of this paper is to demonstrate the use of linear programming as a technique for determining the optimum combination of lumber sizes to be produced from each log size. The underlying objective of course is profit maximization.

Research Procedure

Eleven sawmills located in various parts of North Carolina were visited, and time studies were performed on log-to-lumber conversion of 100 sample logs at each sawmill. In addition, operational procedures of the mills were observed. The general procedure followed in collecting data was:

1. A study of log-processing time
2. A tally of lumber sizes yielded by each sample log
3. Gather general information on mill, power unit, and auxiliary equipment
4. Diagram the complete operation

The logs to be timed were chosen in groups of 10, with each log being scaled by diameter, length, and species on the log deck. When the group of logs had been scaled, the processing time for each log was determined as the logs were sawn.

Total processing time, the total amount of time required to process the log from the log deck until the final dimension was removed from the carriage, was divided into three categories: loading, turning and sawing time. Table 1 is a sample data sheet showing these times as recorded. Loading time constituted the elapsed time required to load the log from the log deck onto the carriage and dog it securely in preparation for sawing. Turning time was the total amount of time required to turn the log while it occupied the carriage in the process of sawing. Total processing time minus loading and turning times constituted the sawing time. No attempt was made to record the down time, since all times recorded were for individual log-processing time.

One recorder was stationed near the front of the mill to observe and time the sawing operation. The second recorder occupied a position at the "green end" to tally the lumber sawed from each log. The different dimensions were tallied by width and thickness, as shown in Table 2. The length was recorded when the logs were scaled on the deck.

Following the collection of the field data, the profits obtained by sawing individual logs into different products were determined. To accomplish this, operating costs for an average small sawmill were determined in accordance with the procedure outlined by Anderson (1).[2]

The average costs of each log were: $43.00 per thousand, which includes stumpage, cutting, and skidding; $9.24 per hour average milling cost; and $5.00 per thousand for the trucking costs from the mill to the concentration yard. The returns from each log were determined by using present market prices for the different lumber dimensions yielded by each log. Net returns to the owner were computed by subtracting the total operating costs from the total returns for each log.

Application of the Technique

A variety of sawing procedures were examined for each log size. To keep the program matrix in reasonable proportions, however, only three sawing procedures were selected for each log size. These methods were selected as follows: 1. Three possible sawing methods that yielded the highest net profit were first examined. 2. When the three methods produced an adequate variety of lumber sizes they were selected. 3. When an adequate variety of lumber sizes was not represented, successively less profitable sawing methods were substituted until all standard widths were represented in the program.

In deciding the best ways to produce lumber from logs, the sawmill operator is limited by certain restrictions. First, there are a number of different log sizes available and a finite total of logs with which to work. Table 3 shows the number of logs included in this program listed by diameter and length. Second, the sawmill operator has to deal with sales restrictions imposed on him by the purchaser of his products. Concentr-

[1] Presented at Session XVI, Quality Control, FPRS 14th Annual Meeting, June 9, 1960, in Montreal, Canada. Revised and approved for publication January 5, 1961.

[2] Numbers in parentheses refer to literature cited from the Selected Bibliography at the end of this article.

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Table 1.—SAMPLE DATA SHEET FOR SAWING OPERATION

Mill #1
Date 7/18/56
Recorder Smith

Log No.	Species	Dia.	Length	% Defect	Loading	Turning	Total proc. time
1	LP	11	16	—	.20	.16	2.00
2	LP	7	14		.15	.10	1.22
3	LP	10	16		.12	.10	1.34
4	SL	10	16		.13	.10	1.36
5	LP	7	14		.12	.10	1.10
6	LP	6	10		.05	.05	.85
7	SL	8	16		.10	.11	1.11
8	SL	10	16	20%	.15	.20	1.69
9	SL	8	14	10%	.19	.14	1.85
10	LP	10	14		.15	.13	1.59
9	LP	9	16		.15	.18	1.68
9	SL	10	10		.12	.15	1.77
9	SL	8	12		.10	.18	1.25
9	LP	10	12		.10	.14	1.68
9	BO	10	10		.15	.19	2.00
10	LP	11	16		.20	.14	2.30

Table 2.—SAMPLE TALLY SHEET

Mill #1
Daye 7/18/56
Recorder Jackson

Log Number	Products 1x3	1x4	1x5	1x6	1x7	1x8	2x4	2x5	2x6	2x8
1		2		1						3
2		2							2	
3				1			1			3
4		1		1						2
5		1						2		
6		2					1			
7		2							2	
8		1					1			2
9	1	1		1					1	
10				1			2			2
95		1					2		2	
96		2		1						3
97		2					1		2	
98		3							1	2
99		1		1		5				
100				1			1		1	2

tic yards located in the area covered by this study buy the entire output of the local sawmills. The sales restrictions stated in this problem are typical of the requirements these concentration yards might impose on the sawmill owner or operator. In fact, the very sales restrictions shown in this problem were obtained from one of these local concentration yards. The sales restrictions are shown and described in Table 4. It should be noted that sales restrictions appear with respect to width of products alone, rather than width and thickness. This is because 1 and 2 inch material were grouped together to keep the program matrix within reasonable proportions. Table 5 shows the demands that each process—log sawing methods—make on the sales restrictions in the manufacturing operation.

For the purpose of calculating the optimum combination of products to manufacture, the processes may be related to the limited resources and sales restrictions by a series of linear inequalities, as shown in Table 6. The first set of equations; that is, the log or resource restriction, states that the combinations of ways of sawing each log size must be equal to, or less than, the number of logs available. Considering the first equation, P_1, P_2, and P_3 each represent a different method of log breakdown for this log size. The number 452 represents the quantity of logs in this size class available for processing.

The sales restrictions can also be expressed as a series of linear inequalities that state that the amount of a specific product manufactured from all the logs that yield that product must be less than, or equal to, a stipulated value. Table 7 shows a series of inequalities that represent the sales restriction. For example, the first equation states that in order to obtain 12,724 board feet or less of 4-inch material, the operator could utilize sawing method 1 to obtain 11 board feet times the number of logs sawed by this particular method. The second component of the equation states that he can obtain 3 board feet times the number of logs sawn by method number 2, 8 board feet times the number of logs sawn by method number 3, and so on throughout the equation.

The 15 linear inequalities can be changed into the form of linear equalities by the addition of slack or waste vectors (P_n) in each of the equations. The slack or waste vectors represent wasted or unused resources. If the slack vectors have a quantitative value in the final basis, it is an indication that some resource has not been utilized or some restriction has not been completely fulfilled.

The profits may also be expressed as a linear equation that states that each log size included in the program multiplied by its associated net profit is equal to the total profit. Table 8 shows the profit function.

These 16 linear equations were solved by the simplex technique of linear programming, as outlined and illustrated by Charnes, Cooper, and Henderson (3). An IBM 650 electronic computer was used to solve the 17 x 50 program matrix. Approximately 17 minutes of machine time were required. A desk calculator can

Table 3.—LOGS AND LOG SPECIFICATION, PROFIT MAXIMIZATION PROBLEM

Log Symbol	Diameter and Length	Number Available
P 1,2,3	6- 8	452
P 4,5,6	6–10	103
P 7,8,9	6–12	385
P 10,11,12	6–16	70
P 13,14,15	8–10	106
P 16,17,18	8–12	100
P 19,20,21	8–14	426
P 22,23,24	8–16	170
P 25,26,27	10–10	66
P 28,29,30	10–14	100
P 31,32,33	10–16	170

Table 4.—SALES RESTRICTIONS, PROFIT MAXIMIZATION PROBLEM

Symbol	Nature of restrictions	Amount of restrictions (board feet)
P 48	Total amount of 4" material that can be sold	12,724
P 46	Total amount of 5" material that can be sold	15,187
P 47	Total amount of 6" material that can be sold	30,000
P 48	Total amount of 8" material that can be sold	17,804

Table 5.—DEMAND OF PROCESSES ON SALES RESTRICTIONS

Process symbol	Dia. and length of log	Sawing method	Board foot content 4" prod.	5" prod.	6" prod.	8" prod.	Associated net returns
P_1	6 8	1	11	0	0	0	$ .14
P_2	6-8	2	3	12	0	0	.12
P_3	6-8	3	8	7	0	0	.04
P_4	6-10	1	0	0	20	0	.46
P_5	6-10	2	10	8	0	0	.05
P_6	6-10	3	3	7	9	0	.19
P_7	6-12	1	3	0	21	0	.36
P_8	6-12	2	3	20	0	0	.13
P_9	6-12	3	20	0	0	0	.09
P_{10}	6–16	1	15	10	0	0	.25
P_{11}	6-16	2	5	27	0	0	.40
P_{12}	6 16	3	28	0	0	0	.28
P_{13}	8–10	1	0	0	24	0	.42
P_{14}	8–10	2	3	0	0	30	.88
P_{15}	8 10	3	0	4	25	0	.34
P_{16}	8-12	1	4	5	30	0	.49
P_{17}	8-12	2	8	0	29	0	.35
P_{18}	8-12	3	4	0	0	32	.10
P_{19}	8 14	1	0	0	0	34	.48
P_{20}	8-14	2	0	17	28	0	.34
P_{21}	8-14	3	13	0	31	0	.24
P_{22}	8-16	1	11	0	32	0	.50
P_{23}	8-16	2	0	0	48	0	.41
P_{24}	8-16	3	16	0	32	0	.20
P_{25}	10–10	1	0	0	15	27	1.12
P_{26}	10–10	2	0	0	0	40	.69
P_{27}	10–10	3	7	8	0	27	.48
P_{28}	10–14	1	14	0	14	37	1.06
P_{29}	10–14	2	0	12	14	37	1.04
P_{30}	10–14	3	9	7	42	0	.60
P_{31}	10–16	1	5	0	8	64	1.54
P_{32}	10–16	2	0	7	55	0	1.05
P_{33}	10–16	3	11	0	8	43	.67

Table 6.—LINEAR INEQUALITIES REPRESENTING RESOURCES RESTRICTIONS

$$
\begin{aligned}
&P_1X_1 + P_2X_2 + P_3X_3 \leq 452\\
&P_4X_4 + P_5X_5 + P_6X_6 \leq 103\\
&P_7X_7 + P_8X_8 + P_9X_9 \leq 385\\
&P_{10}X_{10} + P_{11}X_{11} + P_{12}X_{12} \leq 70\\
&P_{13}X_{13} + P_{14}X_{14} + P_{15}X_{15} \leq 106\\
&P_{16}X_{16} + P_{17}X_{17} + P_{18}X_{18} \leq 100\\
&P_{19}X_{19} + P_{20}X_{20} + P_{21}X_{21} \leq 426\\
&P_{22}X_{22} + P_{23}X_{23} + P_{24}X_{24} \leq 170\\
&P_{25}X_{25} + P_{26}X_{26} + P_{27}X_{27} \leq 66\\
&P_{28}X_{28} + P_{29}X_{29} + P_{30}X_{30} \leq 100\\
&P_{31}X_{31} + P_{32}X_{32} + P_{33}X_{33} \leq 170
\end{aligned}
$$

be used to solve these problems, but it is quite time consuming. Symonds (7) estimates that it takes 4 hours per iteration for a 25 x 50 matrix. If a desk calculator is to be used, probably the most expedient method of keeping the matrix to manageable proportions would be to combine operations as much as possible and include only the most important variables. Another method would be to break the problem into a series of smaller ones.

Table 9 shows the solution by the simplex method under the restrictions previously stated. It can be noted from the final program that all logs have been utilized by one process or another. Note also that the most profitable ways of converting logs were not utilized. If they had been some sales restrictions would have been exceeded, which would result in excessive amounts of certain products for which there would be no market. It should be noted, however, that each restriction has not been completely fulfilled by using all of the log supply. P_{45} and P_{46} are both slack vectors for 4- and 5-inch material. The quantitative value of these slack vectors indicates that, in utilizing the log supply, more profitable log sawing methods were used than those that yielded 4-inch and 5-inch material. The profit from this operation, with the restrictions as stated, is $1,017.12.

Changes in the overall operation, such as changes in raw material quantities new sales restrictions, or changes in net profits necessitate a new program. However, the techniques illustrated previously still apply. The time required to make these changes is not excessive, particularly if an electronic computer is used, because only the data cards dealing directly with the change in operation have to be revised.

Linear programming will provide a positive method of solving complex manufacturing problems involving multiple variables, insofar as the costs of revenues are linearly related to the production level of the processes concerned. Care must be taken in the analysis of the production process to insure that the program calculated will be a valid one. The analysis of the production process may be of real value by itself because some problems may be discovered, for which corrective measures can be taken.

The problem just discussed was relatively simple because the variety of lumber sizes being produced were rather limited. The techniques described would be even more effective where a greater variety of lumber sizes were being produced from larger log sizes.

Linear programming could also be used effectively by a lumber company that had a remanufacturing plant producing a large number of products in addition to lumber. With data on costs, prices, technological restrictions, and market restrictions, linear programming could be used to determine the optimum production combinations, and it would indicate the amount to produce for maximum profits.

These are but two situations where linear programming can be applied. There are many more such situations in the lumber industry where, with careful consideration, linear programming can be another tool to use as an aid in decision making.

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Table 7.—LINEAR INEQUALITIES RESPRESENTING SALES RESTRICTIONS

$$
\begin{aligned}
&11X_1 + 3X_2 + 8X_3 + 10X_5 + 3X_6 + 3X_7 + 3X_8 + 20X_9 + 15X_{10} +\\
&5X_{11} + 28X_{12} + 3X_{14} + 4X_{16} + 8X_{17} + 4X_{18} + 13X_{21} + 11X_{22} +\\
&16X_{24} + 7X_{25} + 14X_{28} + 9X_{30} + 5X_{31} + 11X_{33} \leq 12,724\\
&12X_2 + 7X_3 + 8X_5 + 7X_6 + 20X_8 + 10X_{10} + 27X_{11} + 4X_{15} + 5X_{16} +\\
&17X_{20} + 8X_{23} + 12X_{29} + 7X_{30} \leq 15,187\\
&20X_4 + 9X_6 + 21X_7 + 24X_{13} + 25X_{15} + 30X_{16} + 29X_{17} + 28X_{20} +\\
&31X_{21} + 32X_{22} + 48X_{23} \quad 32X_{24} + 15X_{25} + 14X_{28} + 14X_{29} +\\
&42X_{30} + 8X_{31} + 8X_{33} \leq 30,000\\
&30X_{14} + 32X_{18} + 34X_{19} + 27X_{25} + 40X_{26} + 27X_{27} + 37X_{28} +\\
&37X_{29} + 64X_{31} + 43X_{33} \leq 17,804
\end{aligned}
$$

Table 8.—LINEAR EQUALITY REPRESENTING PROFITS

$$
\begin{aligned}
&\$.14X_1 + .12X_2 + .04X_3 + .46X_4 + .05X_5 + .19X_6 + .36X_7 +\\
&.13X_8 + .09X_9 + .25X_{10} + .40X_{11} + .28X_{12} + .42X_{13} +\\
&.88X_{14} + .34X_{15} + .49X_{16} + .35X_{17} + .10X_{18} + .48X_{19} +\\
&.34X_{20} + .24X_{21} + .50X_{22} + .41X_{23} + .20X_{24} + 1.12X_{25} +\\
&.69X_{26} + .48X_{27} + 1.06X_{28} + 1.04X_{29} + .60X_{30} + 1.54X_{31} +\\
&1.05X_{32} + .67X_{33} = \text{Profit}
\end{aligned}
$$

Table 9.—OPTIMUM PROGRAM OF PROFIT MAXIMIZATION

Process	Dia. and length	Number	Sawing method	Products 1x3	1x4	1x5	1x6	1x7	2x5	2x6	2x8	4x4	4x6
P_1	6–8	452	1									4972	
P_4	6–10	103	1										2060
P_7	6–12	121	1	363						2541			
P_{11}	6–16	70	2		350				1890				
P_{12}	10–16	27	2			189	189	216		432			864
P_{16}	8–12	100	1		400	500	600		5280	2400			
P_{18}	6–12	264	2		792								
P_{22}	8–16	170	1		1870					5440			
P_{25}	10–10	66	1				330	396		660	1782		
P_{28}	10–14	100	1		1400		1400				3700		
P_{31}	10–16	143	1		715		1144				9152		
P_{45}	Waste of 4″ width 1545′												
P_{46}	Waste of 5″ width 23′												
P_{20}	8–14	426	2			7242				11928			
P_{14}	8–10	106	2		318						3180		
Totals				363	5845	7931	3663	612	7170	23410	17814	4972	2924

	Produced	Restrictions
4″	10,817	12,729
5″	15,101	15,187
6″	29,997	30,000
8″	17,814	17,804
	73,729	75,720

Profit = $1,017.12

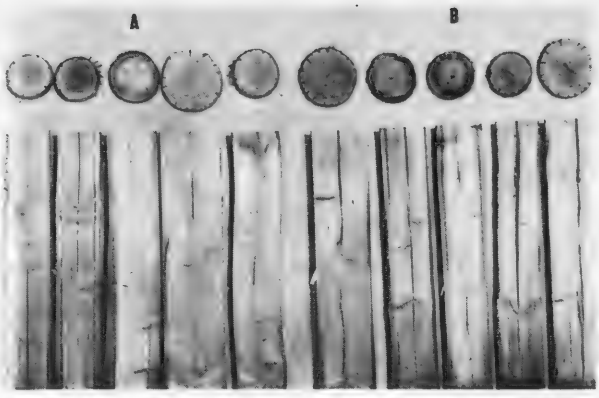

Fig. 1.—Center disks and split half-lengths of round Douglas-fir (coast type) posts to show penetration of preservative in sapwood and heartwood. A, OPM treated. B, full-cell treated.

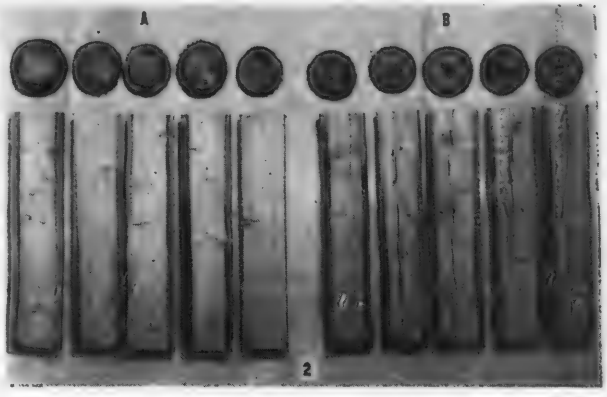

Fig. 2.—Center disks and split half-lengths of round Douglas-fir (intermountain type) posts to show penetration of preservative in sapwood and heartwood. A, OPM treated. B, full-cell treated.

Oscillating Pressure Treatment of 10 U. S. Woods[1]

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Performance of treated wood structures could be improved if preservative penetration in resistant species could be increased. Although the oscillating pressure process was not successful on the heartwood of such woods, it did show improvement over conventional pressure treatment in the unseasoned sapwood of several of the species.

THE OSCILLATING PRESSURE (OPM) PROCESS of the Boliden Mining Company, Skelleftehamn, Sweden, which involves impregnation under a rapid alternating pressure and vacuum cycle,[2,3] provides somewhat better results on green posts from native spruce and Scotch pine of Sweden than conventional pressure impregnation by the full-cell process. Commercial treatment of the heartwood of a number of U. S. species is considerably difficult. The OPM process was thought to offer improvement of treatment results of some of these woods. In 1955, arrangements were made with the Boliden Mining Company through its U. S. representative, Monie S. Hudson, to use OPM equipment in an experimental treatment of 10 U. S. wood species. Early in 1957, treatments by the conventional full-cell process and the OPM process were conducted for comparative purposes at the Forest Products Laboratory, Madison, Wis., in cooperation with the Boliden Mining Company.

The Boliden Mining Company shipped its experimental plant from Sweden to the Laboratory for the duration of the test. The services of Sten T. Henriksson, developer of the process, and Monie S. Hudson were provided also. It supplied the preservative, Boliden salt S–25, and posts and squares of three hardwood species required in the comparative treatments. The Laboratory furnished other equipment and personnel and also arranged for the procurement of posts and squares of the softwoods, which, in some cases, were contributed by commercial producers.

In cooperation with the Taylor–Colquitt Company treating plant at Spartanburg, S. C., where the OPM equipment was moved following the tests at the Laboratory, follow-up treatments were conducted during the early fall of 1957.

In addition to the comparative study of the two treatments at the Laboratory, five posts of each of the 10 species treated by the full-cell and the OPM processes with Boliden salt S–25 and by the empty-cell process with coal-tar creosote were included in a service test installation with untreated control posts at the Harrison Experimental Forest at Saucier, Miss.[4]

[1] A contributed paper approved for publication April 1961.

* Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

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[3] Hudson, M. S. and Henriksson, S. T. 1956. The oscillating pressure method of wood impregnation, For. Prod. Jour., Oct., pp. 381–386.

[4] Blew, J. O., Jr. and Kulp, J. W. 1959. Service records on treated and untreated fence posts, U.S. Forest Products Laboratory Report No. 2005 (revised Oct. 1959).

Posts and Hardwood Squares

Thirty round posts, 5 feet long and 5 to 7 inches in diameter, and thirty 4- by 4-inch by 5-feet all heartwood (see exceptions below) squares were obtained for the study for each of the 10 species treated. The heartwood squares were included to compare results of the two treatments when applied to all heartwood material. The round posts, with normal sapwood thickness, were included to compare the results of treatment on material that contained both sapwood and heartwood. The material was freshly cut and the posts were left unpeeled. All posts and squares were end-coated to retard drying and were shipped to the Laboratory soon after they were cut. The posts and squares were of the following species and from the following sources:

Mockernut hickory *(Carya tomentosa)*, white oak *(Quercus alba)*, and sweetgum *(Liquidambar styraciflua)*; obtained from the Poinsett Lumber and Manufacturing Company, Pickens, S. C., through arrangements by M. S. Hudson, and selected by the Southeastern Forest Experiment Station.

Lodgepole pine *(Pinus contorta)* and Engelmann spruce *(Picea engelmannii)*; obtained from Buckhorn Ranger District, Roosevelt National Forest, Colo., through cooperation of the Rocky Mountain Forest Experiment Station.

Western larch *(Larix occidentalis)* and Douglas-fir (Intermountain) *(Pseudotsuga menziesii* var. *glauca)*; furnished by J. Neils Lumber Company, Libby, Mont., through cooperation of Intermountain Forest Experiment Station.

Western hemlock *(Tsuga heterophylla)*[5] and Douglas-fir (Coast type) *(Pseudotsuga menziesii)*; furnished by McCormick–Baxter Company, Portland, Ore., through cooperation of Pacific Northwest Forest Experimental Station.

Southern pine (possibly shortleaf) *(Pinus echinata)*; obtained from Taylor–Colquitt Company, Spartanburg, S. C.

Included because of special interest of the cooperators were: the southern yellow pine, mostly of sapwood with little resistance to treatment; and the coast type Douglas-fir, and the western hemlock with heartwood moderately resistant to penetration. The heartwood of mockernut hickory is generally resistant to penetration but occasionally has been only moderately difficult to treat. The other species have heartwood that is highly resistant to the penetration of preservatives.

Since it was impracticable to obtain all heartwood squares of southern pine, squares of this species were mixed heartwood and sapwood, as were several of the pieces of Engelmann spruce. Squares furnished as western hemlock were identified as white fir and appeared to be mostly sapwood rather than heartwood. Two heartwood squares, one each included with the two treatments by the OPM process of Douglas-fir (Intermountain), showed preservative retentions much higher than normal and were judged, therefore, to be unrepresentative of that type of Douglas-fir. Results of treatment on these two squares were not included in the averages for Douglas-fir (Intermountain) in Table 1.

The unpeeled and end-coated posts and the end-coated heartwood squares were received at the Laboratory between December 28 and February 11 at a time when weather conditions were not conducive to seasoning of the material. After arrival at the Laboratory, the posts and squares were peeled and close piled outdoors under a tarpaulin. During brief periods of above freezing temperatures, until ready for treatment, the material was sprayed with water to retard drying. Just before treatment, the ends of the posts and squares selected for specific treatments were cut off to remove the end seal. These posts were then stored at a temperature of 80° F. and relative humidity of 97 percent for from 1 to 3 days to permit thawing and to retard moisture loss. At the time the ends were trimmed, cross section disks were taken from one end of each post and square selected for treatment by the OPM process and were used for moisture determinations by the oven drying method. Average moisture content values for each species, size, and OPM treatment are shown in Table . The average moisture content values for the heartwood squares compare favorably, for the most part, with published average values[6] for the heartwood of green material.

Preservative and Treating Solution

The preservative used in this study was copperized chromated zinc arsenate produced and sold by the cooperator as Boliden salt S–25. The product was furnished in a concentrated commercial form which was reported by the cooperator to have the following composition:

Ingredient	Percent
Arsenic pentoxide (As_2O_5)	36.0
Chromic acid (CrO_3)	23.5
Zinc oxide (ZnO)	11.5
Copper oxde (CuO)	3.8
Water (H_2O)	25.2
Total	100.0

The recommendation of the cooperator was followed in the preparation of the treating solutions, and the concentrations were figured on the basis

[5] Squares proved to be white fir (*Abies* sp.).

[6] Wood Handbook (Table 40). 1955. U.S. Department of Agriculture Handbook No. 72.

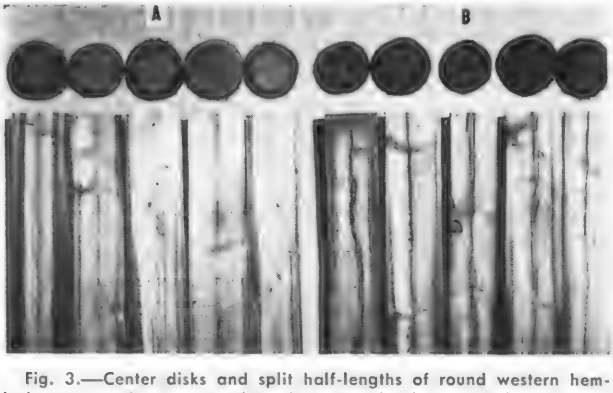

Fig. 3.—Center disks and split half-lengths of round western hemlock posts to show penetration of preservative in sapwood and heartwood. A, OPM treated. B, full-cell treated.

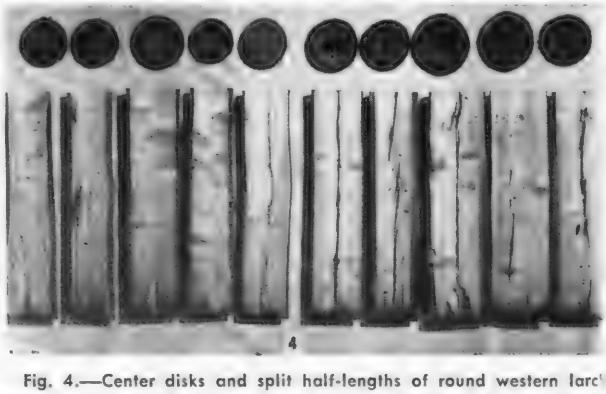

Fig. 4.—Center disks and split half-lengths of round western larch posts to show penetration of preservative in sapwood and heartwood. A, OPM treated. B, full-cell treated.

Table 1.—Results of treatment of round posts and heartwood squares by full-cell and oscillating pressure methods with Boliden preservative S-24

Species and form	Treatment[1]	Average diameter	Average moisture content	Concentration of treating solution[2]	Average preservative retention: Solution	Average preservative retention: Salt	Average sapwood thickness	Average penetration of preservative: Transverse: Sapwood	Average penetration of preservative: Transverse: Heartwood	Average penetration of preservative: Longitudinal: Heartwood
		In.	Percent	Percent	Lb. per cu. ft.	Lb. per cu. ft.	In.	In.	In.	In.
SOFTWOODS										
Douglas-fir (Coast type)	Round: Full-cell (a)	5.9	4.64	11.7	0.54	0.58	0.32		0.98	
	(b)	6.1	5.55	5.89	10.3	.61	.39	.26		
	OPM (a)	5.7	38.6	2.39	1.18	10.2	.12	.66	.35	.70
	(b)	6.0	30.9	2.39	2.44	10.7	.26	.47	.26	
	4x4's: Full-cell (a)		4.64			9.2	.43			
	(b)		5.55	5.89		6.0	.35			
	OPM (a)		29.7	2.39	1.18	11.9	.14		.05	4.0
	(b)		26.4	2.39	2.44	7.9	.19			
Douglas-fir (Intermountain)	Round: Full-cell (a)	6.1	6.58			8.8	.58	.87	.43	.49
	(b)	6.4	6.58	5.67		9.8	.56	(4)	.45	
	OPM (a)	6.7	72.5	1.75	7.11	3.1	.22	1.09	.70	.34
	(b)	6.5	56.0	1.77	4.94	3.2	.16	1.00	.32	
	4x4's: Full-cell (a)		6.58			4.5	.30		.04	.52
	(b)		6.58	5.67		3.1	.29			
	OPM (a)	41.8	1.75	7.11		15.7	.41		1.03	1.50
	(b)	53.0	1.77	4.94		14.9	.24			
Hemlock, western	Round: Full-cell (a)	6.1	3.55			14.0	.50	1.26	.29	2.3
	(b)	5.9	4.64	3.94		14.5	.57	(4)	.24	
	OPM (a)	6.3	61.8	2.28	8.06	10.2	.82	1.14	.61	1.05
	(b)	5.8	75.0	2.38	2.65	11.5	.31	1.14	1.03	
Noble fir	4x4's: Full-cell (a)		3.55			39.5	1.40		2.1	24.0
	(b)		4.64	3.94		40.8	1.61			
	OPM (a)	71.9	2.28	8.06		26.3	2.12		1.21	17.4
	(b)	40.4	2.38	2.65		35.7	.95			
Larch, western	Round: Full-cell (a)	7.2	6.58			7.9	.52	.55	.39	1.24
	(b)	7.2	6.58	5.81		9.0	.52	.74	.31	
	OPM (a)	6.5	57.2	1.70	4.86	7.0	.34	.61	.60	1.3
	(b)	6.8	57.2	1.67	3.66	6.4	.23	.79	.78	
	4x4's: Full-cell (a)		6.58			13.5	.89		.21	2.80
	(b)		6.58	5.81		10.5	.61			
	OPM (a)		60.9	1.70	4.86	16.5	.80		.20	4.35
	(b)		45.9	1.67	3.66	13.1	.48			
Pine, lodgepole	Round: Full-cell (a)	6.4	3.55			17.0	.60	.86	.83	1.17
	(b)	6.0	3.55	2.94		19.4	.57	.75	.66	
	OPM (a)	6.2	56.2	2.08	2.15	7.7	.17	.82	.71	1.15
	(b)	5.9	54.3	2.11	2.51	11.5	.29	1.67	.70	
	4x4's: Full-cell (a)		3.55			13.7	.49		.29	2.62
	(b)		3.55	2.94		14.7	.43			
	OPM (a)	46.2	2.08	2.15		10.2	.22		.21	1.20
	(b)	48.8	2.11	2.51		8.6	.22			
Pine, southern yellow	Round: Full-cell (a)	5.4	4.35			18.3	0.80	2.11	0.69	0.69
	(b)	5.6	3.55	3.14		18.1	.57	2.04	.76	
	OPM (a)	5.6	87.4	2.11	3.38	11.7	.40	2.09	1.87	.35
	(b)	5.5	88.9	2.07	3.41	6.6	.22	2.24	2.00	
	5 4x4's: Full-cell (a)		4.35			27.4	1.19	.90	.92	0.17	.90
	(b)		3.55	3.14		24.3	.77			
	OPM (a)	43.9	2.11	3.38		19.6	.66	.95	.84	.10	.75
	(b)	25.6	2.07	3.41		19.7	.67			
Spruce, Engelmann	Round: Full-cell (a)	6.5	6.58			17.9	1.18	1.22	.58	1.22
	(b)	6.5	6.58	5.42		17.5	.95	(4)	.53	
	OPM (a)	6.1	68.7	1.97	3.26	8.7	.28	(4)	.61	1.05
	(b)	6.4	75.2	2.06	3.45	7.0	.24	(4)	.45	
	4x4's: Full-cell (a)		6.58			12.9	.85		.13	1.2
	(b)		6.58	5.42		10.6	.58			
	OPM (a)	52.4	1.97	3.26		7.4	.24		.08	.96
	(b)	46.1	2.06	3.45		10.9	.38			
HARDWOODS										
Hickory, mockernut	Round: Full-cell (a)	6.7	3.25			9.9	.32		.11	.12
	(b)	6.5	6.58	6.22		6.1	.38	2.97	.15	
	OPM (a)	5.7	37.2	1.50	2.45	14.0	.34	(4)	.09	.08
	(b)	6.4	43.6	1.60	2.84	11.7	.33	2.92	.19	
	4x4's: Full-cell (a)		6.58			5.4	.36		.07	.55
	(b)		6.58	6.03		6.0	.36			
	OPM (a)	56.4	1.50	4.94		8.0	.40		.02	.08
	(b)	57.5	1.70	5.15		6.3	.32			
Oak, white	Round: Full-cell (a)	6.6	6.58			8.7	.57	.61	.21	.12
	(b)	5.8	6.58	6.03		9.0	.54	.53	.36	
	OPM (a)	5.9	60.2	1.50	4.94	6.1	.30	.66	.18	.20
	(b)	6.5	62.9	1.70	5.15	5.4	.28	.61	.14	
	4x4's: Full-cell (a)		3.25			2.5	.08			Not measurable
	(b)		6.58	6.22		2.6	.16			do.
	OPM (a)	64.7	1.50	2.45		3.0	.07			do.
	(b)	68.5	1.60	2.84		3.7	.10			do.
Sweetgum	Round: Full-cell (a)	6.4	3.25			17.8	.58	1.85	.39	.22
	(b)	6.2	3.25	3.28		22.1	.73	3.09	.29	
	OPM (a)	5.9	92.1	2.50	4.02	10.5	.42	2.25	1.91	.15
	(b)	6.2	88.5	2.42	9.56	9.8	.94	2.54	2.18	
	4x4's: Full-cell (a)		3.25			2.8	.09		.04	.52
	(b)		3.25	3.28		4.1	.14			
	OPM (a)	98.9	2.50	4.02		2.7	.11		.08	.64
	(b)	132.0	2.42	9.58		5.2	.50			

[1] Full-cell process after steam and vacuum conditioning; OPM = oscillating pressure method - 22-hour program; (a) = initial or exploratory treatment and (b) = treatment of posts for service test.

[2] Concentration on basis of commercial salts including 25.2 percent of water (by weight). In column 5 - determined when prepared. In column 6 - from analysis of solution after treatment for full-cell treatment and from treating solution used and preservative used as determined from analysis of solutions before and after OPM treatment.

[3] Based on four specimens.

[4] Sapwood difficult to distinguish from heartwood.

[5] Mixed sapwood and heartwood.

of concentrate or actual salts plus combined water, rather than on a water-free basis. Preservative concentrations and retentions shown in Table 1 are reported on a concentrate basis. On a water-free basis, these values would be 74.8 percent of the reported values.

Treating solutions for the full-cell treatments were prepared on a weight basis, while those for the OPM treatments were prepared on the basis of hydrometer readings. Concentrations were adjusted as necessary for the different treatments by the addition of either water or concentrated preservatives. The preservative concentrations on this basis are reported in the fifth column of Table 1. In the sixth column, however, are shown concentrations, based on later chemical analysis by the cooperator, of samples of treating solutions taken during treatment. Except in the case of the full-cell exploratory treatments, where samples of the treating solutions were not taken, these concentrations, based on chemical analysis, were used in computing the retentions of preservative salts as shown in Table 1.

Treatment Procedure

A total of 40 treatments were made to include (a) an exploratory treatment, and (b) a treatment of round posts to be used in a service test, for each of the two methods of treatment and for each of the 10 species. Five round posts and five 4- by 4-inch squares were included in each treatment. The exploratory treatments were used as a basis to determine concentrations needed for desired preservative salt retention of 0.65 pound per cubic foot in the round posts. The posts and squares from each exploratory treatment were used to determine preservative retentions. They were then cut up to measure penetration of preservative and for chemical analyses to show preservative distribution. The posts and squares in the second charge treated by each process were used to determine preservative retentions, and transverse preservative penetration was measured from borings taken from the posts before they were installed in the service test.

A 22-hour OPM schedule was decided upon by the representatives of the Boliden Mining Company. The operation was automatically controlled for the full schedule. First, the cylinder was filled with preservative by a centrifugal pump the pressure was raised quickly to approximately 120 pounds per square inch. Within a few seconds, the second centrifugal pump was started, and a vacuum of approximately 28 inches of mercury was created while some of the preservative was pumped from the treating cylinder. This pressure and vacuum cycle was repeated throughout the 22-hour program.

During the initial phase of the 22-hour program, the pressure and vacuum cycle required about 1 minute, with the time above atmospheric pressure a few seconds longer than the time below atmospheric pressure. The vacuum period was gradually increased. The pressure time was also increased gradually, but to a greater extent than the vacuum, so that near the end of the 22-hour program, the cycles exceeded 360 seconds or approximately 60 seconds for the vacuum and 300 seconds for the pressure time of the cycle.

A treatment schedule for the full-cell process with a waterborne preservative was selected in light of the fact that such treatment is not commonly used on unseasoned hardwoods, except for oaks and sweetgum, and steam conditioning generally is not used or permitted in standards of the American Wood-Preservers' Association, except for the sweetgum and several of the softwoods in the test. Preconditioning was considered essential for the full-cell treatment of the green material, however, and steaming was

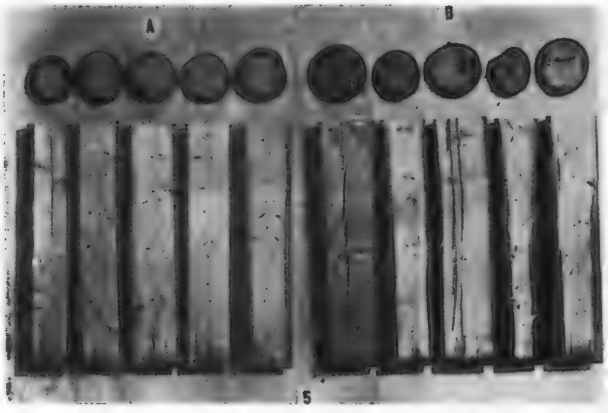

Fig. 5.—Center disks and split half-lengths of round lodgepole pine posts to show penetration of preservative in sapwood and heartwood. A, OPM treated. B, full-cell treated.

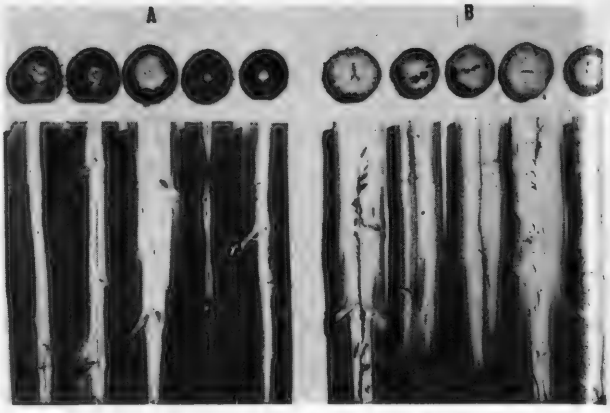

Fig. 6.—Center disks and half-lengths of round southern pine posts to show penetration of preservative in sapwood and heartwood. A, OPM treated. B, full-cell treated.

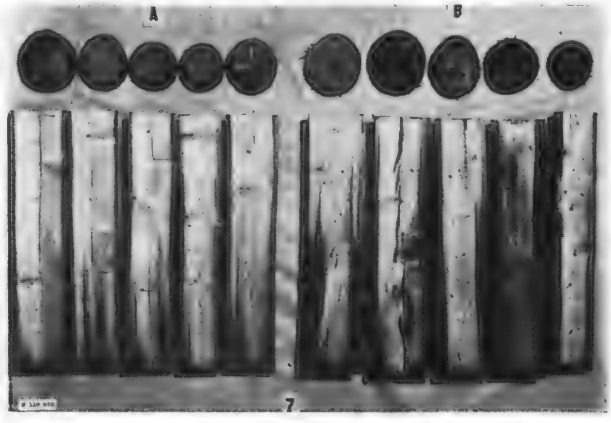

Fig. 7.—Center disks and split half-lengths of round Engelmann spruce posts to show penetration of preservative in sapwood and heartwood. A, OPM treated. B, full-cell treated.

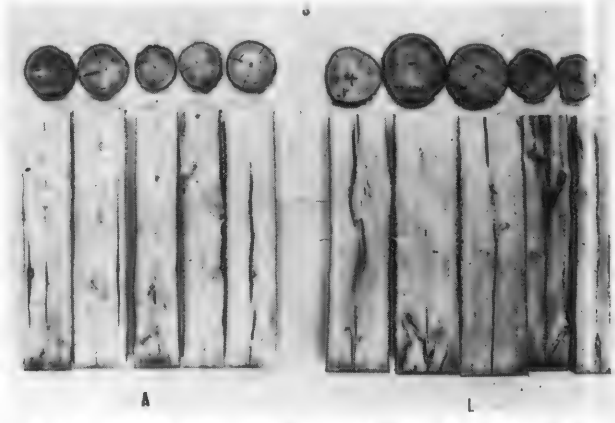

Fig. 8.—Center disks and split half-lengths of round mockernut hickory posts to show penetration of preservative in sapwood and heartwood. A, OPM treated. B, full-cell treated.

selected as the most practicable procedure for common use with all species involved in this comparative test. The following conditioning and full-cell treatment schedule was employed:

(a) Maximum steaming temperature 240° F. except for white oak and mockernut hickory, which were steamed at 212° F. maximum.
(b) Time to raise steam to maximum temperature—1 hour.
(c) Time at maximum temperature —5 hours.
(d) Vacuum after steaming—25 to 26 inches for 1 hour.
(e) Wood allowed to cool overnight to avoid overheating preservative.
(f) Initial vacuum—30 minutes.
(g) Treating pressure: 90 pounds per square inch for 21½ hours; 125 pounds[7] per square inch for ½ hour.

The total pressure period of 22 hours was selected to equal that of the OPM schedule.

The preservative was used without heating in both processes. As indicated previously, the treating solution concentrations for the OPM treatments were controlled by hydrometer readings, and check analyses of the treating solutions were not made until sometime after all of the treatments had been completed. For this reason, the retentions obtained in treating posts of the OPM process did not generally approach the proposed retention (0.65 pound per cubic foot) as closely as those obtained in treating the posts by the full-cell process (Table 1).

Results of Treatment

The results of treatment by the full-cell and OPM processes are shown in Tables 1 and 2 for the round and square samples and in the photographs in Figures 1 to 10 for the round posts. Photographs are not included to show penetration of preservative in the 4- by 4-inch samples since heartwood penetration generally was poor.

[7] 175 pounds per square inch for southern pine, white oak, and sweetgum.

The data on retention of preservative solution and preservative salt are shown in Table 1. Solution retentions were determined from the difference in weights, before and after treatment, on individual posts or squares, divided by the volume of the piece. For most species, the differences in solution retention in the two processes are not significant. In the case of round material of Douglas-fir (Intermountain type), lodgepole pine, southern pine, and Engelmann spruce, solution retentions are significantly higher in the full-cell treatment than those in the OPM process, an indication of the somewhat greater ease in impregnating such material by the full-cell process. For round sweetgum, however, the difference favors the OPM process.

Preservative salt retentions are the product of solution retentions and the concentration of treating solution. This determination method for salt retention is subject to some inaccuracy when green material is treated for long periods, since changes in the concentration of the treatment solution

Table 2.--Results of chemical analyses to indicate the distribution of Boliden preservative S-25 in unseasoned round posts and heartwood squares treated by the full-cell and oscillating pressure (OPM) processes[1]

Species	Zone[2]	Quantities of chemicals in various zones of treated wood																	
		Copper		Zinc		Chromium		Arsenic pentoxide		Copper		Zinc		Chromium		Arsenic pentoxide	
		Full-cell	OPM	Full-cell	OPM	Full-cell	OPM	Full-cell	OPM	Full-cell	OPM	Full-cell	OPM	Full-cell	OPM	Full-cell	OPM
		Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
		SOFTWOODS - ROUND								SOFTWOODS - SQUARES							
Douglas-fir (Coast type)	1	0.120	0.062	0.32	0.24	0.60	0.30	1.66	0.90	0.10	0.067	0.27	0.16	0.60	0.35	1.59	0.97
	2	.028	.015	.16	.13	.13	.10	.37	.27	.002	.003	.017	.015	.008	.008	.032	.061
	3	.023	.047	.14	.14	.12	.18	.34	.46	.0014	.0015	.011	.017	.004	.004	.005	.039
	4	.002	.002	.04	.025	.006	.007	.012	.005	.0004	.0007	.007	.008	.003	.008	.007	.033
	5	.007	.002	.04	.033	.025	.004	.077	.002								
Douglas-fir (Intermountain)	1	.120	.077	.390	.230	.650	.340	1.780	.910	.082	.035	.200	.082	.550	.220	1.300	.510
	2	.005	.015	.045	.130	.020	.100	.070	.250	.099	.00016	.016	.029	.011	.007	.038	.021
	3	.011	.050	.500	.100	.0079	.070	.041	.180	.021	.0001	.110	.021	.0019	.0042	.020	.015
	4	<.0001	.0001	.0032	.057	.003	.002	.014	.015	.0016	.00089	.0081	.032	.0017	.0008	.025	.021
	5	.00045	.0001	.063	.140	.009	.0004	.028	.023								
Hemlock, western[3]	1	.060	.11	.250	.32	.32	.46	.960	1.250	.290	.20	.800	.560	1.130	.87	3.340	2.480
	2	.0008	.031	.030	.21	.018	.20	.078	.530	.180	.105	.580	.300	.690	.38	2.130	1.100
	3	.0003	.035	.040	.088	.028	.036	.100	.130	.140	.094	.530	.250	.560	.34	1.810	.960
	4	.0014	<.0001	.056	.022	.036	.0031	.120	.023	.160	.089	.550	.250	.620	.31	1.900	.880
	5	.017	.004	.080	.02	.057	.006	.190	.030								
Larch, western	1	.14	.18	.38	.43	.78	.66	2.08	1.84	.26	.066	.67	.20	1.23	.33	3.23	.99
	2	.028	.16	.17	.20	.14	.39	.43	1.07	.029	.007	.20	.08	.14	.037	.45	.13
	3	.347	.21	.19	.50	.15	.46	.51	1.36	.008	.002	.064	.066	.024	.009	.13	.066
	4	.002	.002	.07	.06	.005	.006	.013	.012	<.001	.001	.058	.065	.001		.014	.038
	5	.004	.006	.08	.05	.017	.002	.054	.005								
Pine, lodgepole	1	.27	.21	.72	.43	1.46	.77	3.05	1.97	.11	.099	.33	.33	.49	.38	1.39	1.04
	2	.098	.24	.41	.37	.37	.41	1.20	1.21	.022	.018	.17	.21	.083	.074	.25	.23
	3	.045	.026	.16	.30	.14	.14	.55	.47	.013	.0033	.0011	.026	.054	.022	.15	.072
	4	.001	<.001	.12	.11	.007	.002	.07	.010	.0073	.0015	.01	.057	.026	.013	.11	.058
	5	.005	<.001	.01	<.01	.019	.00	.078	.00								
Pine, southern yellow	1	.12	.15	.35	.37	.46	.50	1.30	1.32	.14	.19	.44	.30	.54	.51	1.48	1.33
	2	.0098	.15	.12	.29	.040	.37	.13	1.04	.024	.004	.24	.019	.14	.031	.57	.18
	3	.0069	.075	.15	.25	.032	.22	.046	.31	.004	.001	.125	.007	.042	.007	.23	.094
	4	.0021	.0022	.0028	<.01	.031	.011	.089	.07	.002	.00	.031	.003	.013	.039	.11	.036
Spruce, Engelmann	1	.09	.21	.54	.55	.84	.82	2.43	2.15	.14	.068	.36	.20	.77	.29	1.99	.77
	2	.029	.094	.21	.37	.14	.28	.50	.98	.042	.0027	.15	.08	.24	.023	.63	.065
	3	.0062	.003	.14	.23	.078	.086	.27	.33	.0085	.0036	.20	.22	.014	<.008	.12	.041
	4	.0039	.000	.076	.017	.008	.006	.028	.036	.0006	.0032	.17	.02	.012	<.008	.044	.028
	5	.0072	.001	.06	.020	.040	.000	.11	.003								
		HARDWOODS - ROUND								HARDWOODS - SQUARES							
Hickory, mockernut	1	.004	.024	.12	.06	.43	.17	.37	.34	.02	<.003	.30	.41	.31	.15	.71	.30
	2	.003	.0008	.02	.02	.012	<.008	.030	.043	.003	.003	.51	.60	.027	.024	.08	.07
	3	.011	<.0002	.06	.02	.052	<.008	.17	.027	.003	.003	.51	.52	.019	.027	.06	.07
	4	.03	<.003	.63	1.5	.24	.024	.66	.04	.003	.003	.17	.04	.032	.022	.097	.06
Oak, white	1	.13	.09	.17	.20	.74	.33	2.00	.79	.039	.015	.382	.329	.45	.16	.56	.30
	2	.035	.003	.23	.20	.17	.07	.54	.18	<.0006	.0006	.040	.018	.008	<.008	.031	.019
	3	<.019	.003	.16	.20	.10	.035	.35	.095	<.0006	.0006	.086	.018	.008	<.008	.025	.023
	4	<.0006	.0006	.035	.10	.008	<.008	.018	.016	<.0006	.0006	.10	.053	.008	<.008	.015	.015
	5	<.0014	.0006	.062	.024	.008	<.008	.035	.007								
Sweetgum	1	.020	.061	.21	.26	.11	.45	.30	.66	.054	.03	.153	.46	.45	.20	.388	.47
	2	.032	.061	.053	.20	.019	.21	.074	.52	.0006	<.0006	.01	<.01	.002	<.002	.001	.005
	3	.035	.093	.028	.27	.042	.28	.16	.73	.0006	<.0006	.01	<.01	.002	<.002	.001	.002
	4	.013	.004	.051	.13	.069	.013	.22	.049	.0006	<.0006	.01	<.01	.002	<.002	.001	.002

[1] Analyses by Bolidens Gruvaktiebolag, Skelleftehamn, Sweden.

[2] Round posts (pie section sample (2-inch tangential)):
Zone 1 - outer one-third of sapwood depth
2 - middle one-third of sapwood depth
3 - inner one-third of sapwood depth
4 - first 1/2 inch of heartwood
5 - balance of heartwood to pith center.
Squares (2-inch wide center sample, one-half the thickness of the 4- by 4-inch square):
Zone 1 - outer 1/4 inch
2 - second 1/4 inch
3 - third 1/4 inch
4 - remaining 1-1/4 inch to center.

[3] White fir used instead of western hemlock for the squares.

can occur through diffusion of the chemicals into the wood. Salt retentions determined on the basis of solution weights and concentrations before and after treatment, however, would not show the quantities of preservative retained by individual pieces or by the round and square material in the same charge. These salt retention values can, of course, be adjusted by a change in the concentration of the treatment solution. They are not necessarily an important factor to compare methods of application unless retention levels of accepted standards cannot be obtained. In heartwood squares of species, such as white oak and sweetgum, there were indications that difficulty could be expected to attain a preservative retention as high as 0.65 pound per cubic foot in both full-cell and OPM processes.

The transverse and longitudinal penetration of preservative shown by the values in Table 1 and the round treated sections illustrated in Figures 1 to 10, along with the results given in Table 2 which show distribution of the chemicals in different zones of the treated specimens, furnish a good basis for comparison of the two processes on the various species. Transverse penetrations were measured from 2-inch-thick disks taken from the midpoint, or 2½ feet from the end of the 5-foot posts and squares. The remaining 2½ foot length was split open to show both transverse and longitudinal penetration at the split faces. Additional 2-inch-thick cross sections of posts and squares, taken adjacent to the first, were cut into zone sections for chemical analyses to show preservative distribution. In the case of the round posts, a pie section 2 inches wide at the circumference of the post was cut from each disk. The sapwood was then divided into three zones of equal depth, and two other zones that comprised the outer ½ inch of heart-

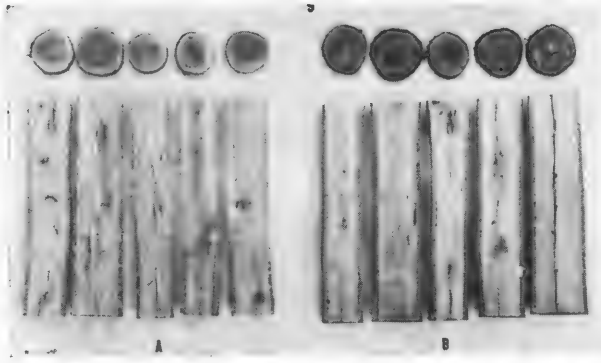

Fig. 9.—Center disks and split half-lengths of round white oak posts to show penetration of preservative in sapwood and heartwood. A, OPM treated. B, full-cell treated.

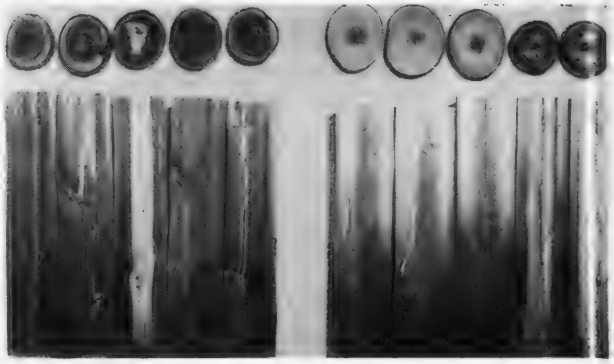

Fig. 10.—Center disks and split half-lengths of round sweetgum posts to show penetration of preservative in sapwood and heartwood. A, OPM treated. B, full-cell treated.

wood and the balance of the heartwood were sampled.

In the case of the cross section disks from the 4- by 4-inch squares, a 2-inch-wide by 2-inch-thick section was taken from the middle of one face (1 inch from each side) to the center of the 4 by 4. The outer ¼ inch, the second ¼ inch, and third ¼ inch, and the remaining 1¼ inch to the center of the 4 by 4 comprised the four zones taken for analysis and reported in Table 2. Method 3 in AWPA Standard A3–58 to determine penetration of zinc-containing preservatives was used to facilitate measurement of preservative penetration and to prepare the midpoint cross section of the posts for the photographs (Figures 1 to 10).

The results on 4- by 4-inch heartwood given in Tables 1 and 2 show no significant improvement in preservative penetration and distribution obtained with the OPM process in comparison with that obtained with the full-cell process used. With a retention of 0.65 pound per cubic foot for Boliden salt S–25, the retention of arsenic pentoxide (As_2O_5) should be 0.27 pound per cubic foot, or 0.67 percent and 1.4 percent respectively, based on the weight of the heaviest oven-dry wood, mockernut hickory, and that of the lightest wood, Engelmann spruce. It is estimated by the Boliden Mining Company that an arsenic pentoxide concentration of at least 0.1 percent is desirable for adequate protection of wood. The data in Table 2 for the 4- by 4-inch squares show this concentration generally was not obtained in either process, particularly with the species that were entirely of heartwood.

The data that relates to the round posts and photographs indicate some improvement in the preservative penetration and distribution obtained with the OPM process in comparison with that obtained with the full-cell process in the sapwood of the Intermountain Douglas-fir, western hemlock, western larch, southern yellow pine, Engelmann spruce, and sweetgum.

Results of Supplemental Study at Spartanburg, S.C.

The OPM equipment, as previously mentioned, was moved to the Taylor–Colquitt Company plant at Spartanburg, S. C., following the treatments at the Forest Products Laboratory. Additional treatments then were made on round posts, 8½ feet long and 5 to 6 inches in diameter, of pondcypress *(Taxodium distchum* var. *nutans)*, shortleaf pine *(Pinus echinata)*, and sweetgum *(Liquidambar styraciflua)*. Of these woods, pondcypress was of interest because of its abundance for post and pole use in the southeastern states and because of the difficulties in air seasoning and in obtaining satisfactory penetration of preservative through conventional pressure treatment in round, green material. The other two species had shown promising results through OPM treatment at the Laboratory on 5-foot-long round material, so it was of interest to determine if this improvement could be expected in material of longer lengths, such as that used for crossties.

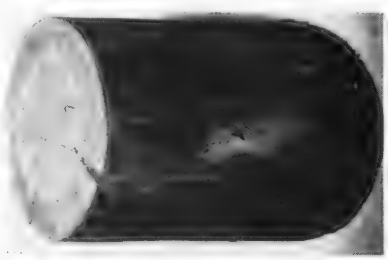

Fig. 11.—Section of OPM treated round Douglas-fir (intermountain type) showing check and exposure of unpenetrated center after treatment. This is an objectionable feature of treating unseasoned round material of thin sapwood species.

The treatments were conducted at Spartanburg by M. Sarwat Husain, research associate, who represented the Forest Products Laboratory, under the supervision of Monie S. Hudson. Green posts of the three species were conditioned and treated in 13 charges as follows:

Charge No.	Conditioning	Treatment	Treating Time Hours
	Pondcypress		
1 and 2	None	OPM process	22
3	Steam conditioned	Full-cell process	22
4	Steam conditioned	OPM process	22
	Sweetgum		
5	None	OPM process	8
6	Steam conditioned	OPM process	8
7	Vapor dried	Full-cell process	8
8	Vapor dried	OPM process	8
9	Steam conditioned	Full-cell process	8
	Shortleaf Pine		
10	None	OPM process	8
11	Vapor dried	OPM process	8
12	Steam conditioned	Full-cell process	8
13	Vapor dried	Full-cell process	8

The full-cell process was applied with the posts in the special OPM equipment, so treating pressures were the same (approximately 120 pounds per square inch) for both processes. The steam conditioning was at a maximum temperature of 240° F. for 4 hours, after an hour had been taken to arrive at that temperature. Otherwise, conditioning and treatment schedules were similar to those used earlier at the Laboratory. The steamed posts were allowed to cool overnight before the full-cell and OPM treatments, but those that were vapor dried were treated soon after they were conditioned.

Cross sections from the middle of the posts were examined for penetration. Sections for chemical analyses were cut in successive 1-centimeter zones, beginning at the circumference. Data in Table 3 show the average, minimum, and maximum quantities of arsenic pentoxide (As_2O_5) found by analysis in the seven 1-centimeter-thick zones of the round material.

Penetration of preservative in the sapwood in the various treatments, as noted from stained (AWPA Standard A3-58, Method 3) cross sections, was somewhat erratic in pondcypress and sweetgum and generally deeper and more uniform in the shortleaf pine.

Pondcypress: In the two charges (1 and 2) of pondcypress posts similarly treated by the OPM process without conditioning, penetrations were not uniformly good. For some reason, however, they appeared better in charge 1 than in charge 2. The best penetration of the sapwood of pondcypress was noted in charge 4, where steam conditioning was used before the OPM treatment, but even here two out of six posts showed poor or erratic penetration.

Values in Table 3 from the various treatments of pondcypress show preservative distribution to be most favorable in those posts which were steam conditioned and treated by the OPM process. In the pondcypress posts that were steam conditioned and full-cell treated, the quantity of preservative present in the first 3-centimeter zones was less, but somewhat greater in the inner zones than that found in the OPM treated posts which had not been steam conditioned.

Sweetgum: In the sweetgum posts that were steam conditioned and vapor dried, sapwood penetrations and distribution appeared better in the OPM treatment than in the full-cell treatment. In all treatments of sweetgum, however, penetrations, as photographed, were either poor or erratic. With the 8-hour treating schedule, the significant improvement in OPM treatment without conditioning that was noted over steaming and full-cell treatment in the 5-foot long posts was not found in the 8½ foot long material.

The steam conditioned sweetgum posts treated by the OPM process showed more uniform distribution of preservative throughout the cross section than those with other treatments, although the quantity of preservative found between the first and fifth centimeter zones was somewhat higher in the full-cell and OPM treatments on vapor dried posts. Poorest distribution occurred in the sweetgum posts that were steam conditioned and treated by the full-cell process, which in all zones showed the lowest percentage of arsenic pentoxide.

Shortleaf pine: In the shortleaf pine posts that were vapor dried, sapwood penetration and distribution of arsenic pentoxide appeared better after full-cell treatment than with treatment by the OPM process, and better in both cases than with steam conditioning and full-cell treatment. The OPM process on unconditioned, green shortleaf pine showed higher arsenic concentration than the pine posts that were steam conditioned and treated by the full-cell process. The OPM process also appeared to result in more uniform penetration of the springwood and summerwood in the outer zone but less penetration of the sapwood depth and lower preservative concentration in the inner zones than the pine posts steam conditioned and treated by the full-cell process. Here again, the improvement in sapwood penetration noted for the 22-hour OPM schedule over the full-cell process when used on green 5-foot-long posts was not noted in the 8½-foot posts treated with the OPM 8-hour schedule. The arsenic pentoxide found in the inner zones was somewhat low in both treatments.

Summary

The primary objective of this study was to determine possible benefits of the OPM process to improve preservative penetration in the heartwood of highly resistant species. The study showed no significant improvement, as far as the OPM process was concerned, in the treatment of the 4- by 4-inch squares, which, for the most part, were heartwood.

Sapwood penetration of Boliden salt S–25 in 5-foot long round, green posts of Intermountain-type Douglas-fir, western hemlock, western larch, southern yellow pine, Engelmann spruce, and sweetgum was somewhat better after OPM treatment than was noted after steam conditioning and full-cell treatment. This improvement, however, has questionable value in the case of thin sapwood western softwoods, since the green treated material could be expected to develop checks in seasoning after treatment and thereby expose the unpenetrated

Table 3.--Results of chemical analyses to indicate the distribution of Boliden preservative in round posts treated by the full cell and oscillating pressure (OPM) processes at Spartanburg, S.C.[4]

Charge No.	Number of posts	Conditioning	Treatment	Retention of preservative[2]	Percentage of arsenic pentoxide (As_2O_5)																					
					1st centimeter zone			2d centimeter zone			3d centimeter zone			4th centimeter zone			5th centimeter zone			6th centimeter zone			7th centimeter zone		
					Mini-mum	Maxi-mum	Aver-age	Mini-mum	Maxi-mum	Aver-age	Mini-mum	Maxi-mum	Aver-age	Mini-mum	Maxi-mum	Aver-age	Mini-mum	Maxi-mum	Aver-age	Mini-mum	Maxi-mum	Aver-age	Mini-mum	Maxi-mum	Aver-age
				Lb. per cu. ft.																						
PONDCYPRESS																										
1	3	None	OPM	0.56	1.15	2.80	2.12	0.13	1.20	0.70	0.15	0.33	0.22	0.08	0.13	0.10	0.03	0.06	0.05	0.04	0.34	0.04	0.05	0.44	0.25(4)[3]
2	6	None	OPM	.58	.50	1.40	.90	.05	.16	.11	.05	.09	.07	.03	.07	.05	.02	.06	.04	.03	.46	.10	.04	.34	.14(4)
3	5	Steaming	Full cell	.36	.25	.60	.42	.04	.07	.05	.05	.14	.08	.05	.11	.06	.04	.39	.15	.06	.20	.12(4)	.....	1.10	1.10(1)
4	6	Steaming	OPM	2.08	.34	2.50	1.39	.13	1.70	.84	.04	.77	.34	.05	.80	.28	.04	.47	.15	.07	.77	.38	.52	.88	.78(3)
SWEETGUM																										
5	5	None	OPM	.77	.47	.77	.57	.07	.22	.13	.07	.24	.15	.04	.38	.17	.04	.41	.22	.05	.40	.27	.05	.30	.18(3)
6	5	Steaming	OPM	2.29	.60	1.50	.94	.06	.44	.21	.06	.30	.15	.06	.54	.29	.24	.72	.52	.42	.95	.57	.69	.96	.82(2)
7	6	Vapor dried	Full cell	1.04	.45	.77	.65	.20	.58	.41	.30	.61	.41	.15	.83	.35	.08	.82	.28	.11	.74	.34	.....	.35	.35(1)
8	5	Vapor dried	OPM	1.19	.74	1.15	.86	.30	.78	.49	.27	.79	.53	.16	.72	.37	.13	1.02	.39	.21	1.00	.39	.24	.76	.45(4)
9	5	Steaming	Full cell	.21	.21	.45	.29	.03	.12	.06	.03	.10	.05	.03	.07	.04	.02	.10	.05	.02	.17	.07	.....	.04	.04(1)
SHORTLEAF PINE																										
10	6	None	OPM	.21	1.02	1.70	1.30	.13	.96	.38	.03	.64	.17	.03	.34	.08	.03	.12	.05	.02	.06	.03	.02	.04	.03(3)
11	6	Vapor dried	OPM	.70	1.10	1.50	1.33	.44	.80	.66	.14	.36	.29	.10	.32	.20	.16	.31	.22	.18	.68	.38	.....	.28	.28(1)
12	6	Steaming	Full cell	.59	.28	.48	.36	.17	.30	.22	.07	.16	.10	.03	.07	.05	.03	.07	.05	.03	.17	.08(5)	.05	.09	.07(4)
13	6	Vapor dried	Full cell	.65	.36	1.15	.90	.22	.70	.54	.08	.62	.46	.06	.62	.46	.08	.78	.54	.08	.34	.60	.47	.55	.53(3)

[1] Reported by Bolidens Gruvaktiebolag, Skelleftehamn, Sweden.

[2] Based on weights of posts before and after treatment.

[3] Number of samples in average.

interior to attack by decay fungi or harmful insects (Figure 11). In the case of the thick sapwood sourthern species of southern pine and sweetgum, however, such checking after treatment would be much less serious than with the thin sapwood species. These southern woods, furthermore, are frequently difficult to adequately air season for treatment without fungus infection. In the supplementary treatment of shortleaf pine and sweetgum posts of the longer 8½ foot length, however, the OPM treatment did not result in complete or uniform penetration of the sapwood, nor did it show significantly improved results over the conventional full-cell process on steam conditioned material. It is unfortunate that the 22-hour OPM schedule as used for the 5-foot lengths was not used on the longer material, since this factor may have had some influence on the results.

The results of the OPM process on pondcypress, another thick sapwood southern species that is difficult to air season properly for treatment, were also unsatisfactory.

The results of treating round sweetgum and shortleaf pine by both the OPM and full-cell processes after vapor drying were improved over those that treated steam conditioned material by both processes or that treated green unconditioned material by the OPM process. This and the satisfactory experience in the conventional pressure treatment of properly air seasoned sapwood of southern pine, sweetgum, and baldcypress, indicates that the sapwood moisture content must be reduced considerably in these woods for satisfactory penetration to result in treatments principally of the pressure type.

Natural Decay Resistance of Guijo[1]

THEODORE C. SCHEFFER and
WALLACE E. ESLYN

Forest Products Laboratory,[2] Forest Service
U. S. Department of Agriculture

RESULTS OF SOIL-BLOCK TESTING OF GUIJO HEARTWOOD SAMPLES FROM THREE TREES

Tree and diameter inside bark at stump	locality	Height of sample in tree, feet	Average weight loss[1] caused by indicated fungus, percent: *Polyporus versicolor* (Mad. 697)	*Poria monticola* (Mad. 698)	*Lenzites trabea* (Mad. 617)
No. 119, 23 inches	Famy, Laguna Prov.	11	5	5	5
		35 to 41	9	10	8
No. 160, 20 inches	Makiling National Park				
		35	16	12	11
No. 169, 36 inches	Florida, Agusan Prov.	8	7	6	6
		39 to 90	15	12	8

[1]Each average for the lower trunk represents 4 determinations; and for the upper trunk, 8 determinations on tree 119, 4 on tree 160, and 16 on tree 169.

IN AN INVESTIGATION of the decay resistance of several commercial mahoganies,[3] the true mahoganies *Swietenia mahagoni* and *S. macrophylla* proved generally resistant or highly resistant, whereas African mahogany *(Khaya* spp) and most of the Philippine mahoganies (Shorea, Parashorea, and Dipterocarpus species) exhibited usually no more than moderate resistance. An exception, however, was guigo *(Shorea guiso),* a Philippine species that was as resistant as the true mahoganies. Guijo was represented by only two boards from a single source, however, which left doubt as to whether this resistance was typical.

Through the courtesy of the Philippine Forest Products Research Institute and George M. Hunt, advisor, board samples from three additional guijo trees were made available for testing. The results reported here substantiate the earlier evidence that guijo heartwood tends to be resistant or highly resistant to decay. Some variation in resistance occurred with position of the wood in the tree, as will be noted.

Research was carried out by the soil-block method, using procedures basically similar to those of ASTM Designation 1413–56T for appraising wood preservatives. The method entailed exposure for 12 weeks of small blocks (in this case 1 by 1 by ⅜ inches) to pure cultures of fungi growing on a subtrate of sapwood and soil. Three standard test fungi were used in the experiment. Decay was measured by the loss of dry weight of the blocks.

Weight losses caused by the respective fungi are shown in the Table. These losses may be interpreted in terms of the following general classes of resistance to decay by a particular fungus: 0 to 10 percent loss, highly resistant; 11 to 24 percent loss, resistant; 25 to 44 percent loss, moderately resistant; and 45 percent or more loss, slightly resistant. These relations have been developed from a substantial background of soil-block testing.

The samples, without exception, were either resistant or highly resistant to all three fungi. Those from 35 feet or higher in the trunk tended to be a little less resistant than those from the lower part of the trunk. Likewise, although not shown in the Table, samples from the outer heartwood were slightly more resistant than those deeper in the heartwood. Both situations correspond to trends that have been observed in certain other woods.

The Authors: T. C. Scheffer and W. E. Esyln are both pathologists at the U. S. Forest Products Laboratory, Madison, Wis.

[1] A contributed paper approved for publication April, 1961.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[3] Moses, C. S. 1955. Laboratory test of some commercial species of mahogany. For. Prod. Jour. 5(2): 149–152.

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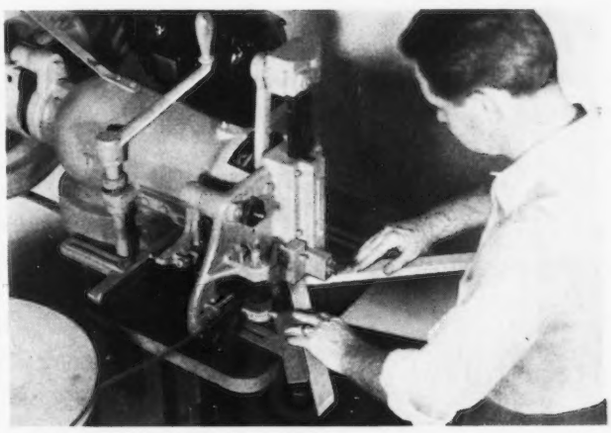

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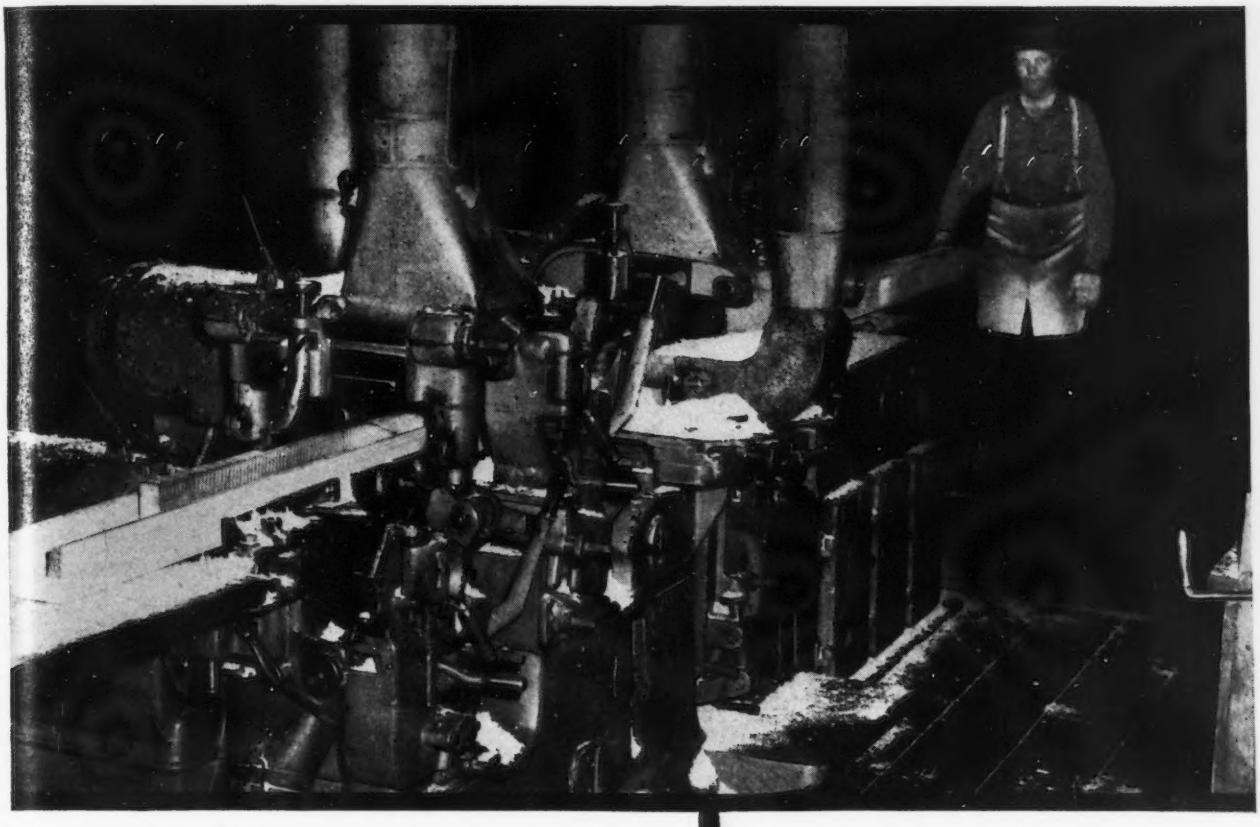

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MATTISON
MACHINE WORKS
ROCKFORD ILL. U.S.A.

MATTISON
WOODWORKING MACHINERY
"Built better . . . to produce better quality"

MATTISON MACHINE WORKS
545 Blackhawk Park Avenue, Rockford, Illinois
Gentlemen:
Please send free literature describing your No. 229 Electric Moulder.

Name_____

Firm_____

Address_____

City_____ Zone____ State_____

Circle Item 2, Reader Service Form

ELMER BERGEY directs our research in the new Riverton, N.J. laboratory. He's our technical expert on urea, casein, poly-vinyl, resorcinol and phenolic glues . . . how they work and why!

BOB ETIEN helps customers in Eastern Texas, Louisiana, Mississippi, Arkansas and Memphis, Tennessee.

BOB COUSINS watches out for our woodworking friends in New York City, Northern New Jersey and New England.

GEORGE TASKER calls on plants in lower Michigan, Northern Indiana, Ohio and the eastern half of Chicago.

BART THIELGES is our Sales Manager. Keeps us running in the right directions. Also keeps us informed with the latest information on our woodworking glues . . . Tips that help customers' production!

DR. TOM COOK is our President. He quarterbacks our entire operation. Comes up with ideas like strategically-locating our four distribution points to provide same-day service to customers!

Why are National Casein's glue men always running?

Lots of reasons! They're specially trained to solve woodworking problems on the job...*so you don't have to hold up production!* Sometimes they're running for better deliveries for your glue orders. Other times to run down a gremlin in your production line. Often just to be sure you're using the right glue for the right job. **Always to serve you better with the best of glues!**

National Casein

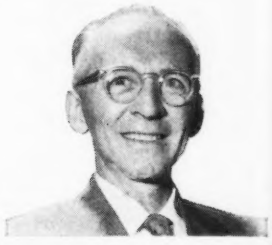
National Casein Company, 601 W. 80th Street, Chicago 20, Illinois and Tyler, Texas

National Casein of New Jersey, Broad & Fulton Sts., Riverton, New Jersey

FRED ATKINSON services the woodworking plants in Wisconsin, Minnesota and upper Michigan.

BOB ALLEN travels to and from our customers' plants in Southern Illinois and Indiana, Kentucky, Tennessee and St. Louis.

ELMER EVANS manages our New Jersey plant. He backs up our East Coast salesmen . . . helps them come up with answers to the problems of their woodworking customers.



O. B. (OBIE) DERR is our glue man for woodworking industries in Pennsylvania, W. Virginia, New York, New Jersey and Maryland.

BOB ARCHAMBEAULT takes care of our woodworking customers in Chicago, Northern Illinois and Iowa.

RON LONG assists woodworkers in Virginia, Maryland, Delaware and Southern New Jersey.

Circle Item 3, Reader Service Form